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# Wilderness Fire Management Planning Guide

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## RESEARCH SUMMARY

Current fire management policies of Federal land management agencies generally recognize fire as a natural process in many forest and range ecosystems, especially in the West. Consequently, fire is allowed or encouraged to more nearly play its natural role in wildernesses, parks, refuges, and other areas managed in whole or in part to maintain primitive or presettlement conditions. The tasks associated with such policies are collectively known as wilderness fire management.

In this report, wilderness fire management is defined as the deliberate response to and use of fire through the execution of technically sound plans under specific prescriptions for the purpose of achieving stated wilderness management objectives. Four types of manager response to fire are identified: aggressive attack, delayed attack, modified attack, and allowing a fire to burn according to a predetermined prescription. Wilderness fire management planning is the process of determining the appropriate response to accidental fire and the use of manager-initiated fire to accomplish wilderness management objectives.

This report attempts to guide wilderness fire management planning by suggesting a common terminology, examining important planning concepts, and identifying, describing, and discussing essential planning elements.

Among the planning concepts examined are the appropriate planning area, the planning context, and the format and content of the wilderness fire management plan. Special attention is given to the relationship of the wilderness fire management plan to the various other plans that exist in the planning hierarchy of most agencies. The relationship between National Environmental Policy Act (NEPA) requirements and wilderness fire management planning is illustrated using the Forest Service NEPA process as an example.

Wilderness fire management planning is separated into six essential elements in this report:

1. Describing fire and ecosystem interactions
2. Describing special resource and use considerations
3. Defining fire management objectives
4. Delineating fire management units and zones
5. Developing fire management prescriptions
6. Devising a fire management plan

Each of these planning elements is defined and discussed in terms of planning approach, information needs, and methods of presentation. Appropriate examples for actual wilderness fire management plans are presented to illustrate methods.

A summary of current wilderness fire management programs in the National Parks and National Forests is presented as an appendix. A second appendix provides a bibliographic listing of selected references for park and wilderness fire management. References are grouped according to seven subject areas: philosophy, programs, and plans; planning aids and general information sources; fire history; fire occurrence, fire environment, and fire behavior; the role of fire and fire effects; vegetation inventory, classification, and analysis; and ecosystem classification.

## CONTENTS

	Page
Introduction .....	1
Evolution of Wilderness Fire Management Policy .....	1
Wilderness Policy .....	1
Fire Management .....	2
Wilderness Fire Management.....	2
Planning Concepts.....	4
Planning Area .....	4
Planning Context.....	5
The Plan.....	9
Planning Elements .....	9
Fire and Ecosystem Interactions .....	9
Special Resource and Use Considerations .....	19
Fire Management Objectives .....	19
Fire Management Units and Zones .....	20
Fire Management Prescriptions .....	22
Fire Management Plan .....	25
References .....	28
Appendix A: Park and Wilderness Fire Management Programs, 1972-81 .....	33
Appendix B: Selected References for Park and Wilderness Fire Management Planning .....	37
Philosophy Programs and Plans .....	37
General Planning Aids and Information Sources ...	39
Fire History .....	41
Fire Occurrence, Fire Environment, and Fire Behavior .....	44
The Role of Fire and Fire Effects .....	47
Vegetation Inventory, Classification, and Analysis..	53
Ecosystem Classification .....	56

# Wilderness Fire Management Planning Guide

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## INTRODUCTION

The purpose of this report is to guide and aid fire management planning for parks, wildernesses, and other wild, natural, or essentially undeveloped areas. A philosophy and general approach to wilderness fire management planning is emphasized. The intent is not to propose a rigid format or to specify particular methods. Wilderness fire management plans, like the areas they represent, will vary in content, complexity, and scope. Nevertheless, wilderness fire management plans should share a common purpose and uniform planning procedure.

The suggested approach to wilderness fire management planning is essentially a two-step process. The first step involves developing specific fire management objectives based on agency policy, management direction, the physical and biological characteristics of the planning area, the probable ecological effects of fires and the absence of fire, and the likely effects of different fire suppression actions on the environment. The second step is to translate the specific fire management objectives into planned actions for responding to fire or for the use of fire on specific lands within the planning area.

It is important to note that this is a planning guide. It is not a policy implementation guide. Its utility, therefore, is not limited to a particular agency. In other words, this guide was written with the hope that all fire management agencies would find it equally useful as a common reference for fire management planning.

Wilderness fire management is a relatively new activity. A universally accepted terminology is, consequently, lacking. Different terms are often used to identify identical processes. Conversely, identical terms are often used to identify different processes. Definitions are often unrelated to the literal meaning of the terminology. The terms used in this guide are based on standard dictionary definitions. The goal is to provide a terminology that is both logical and easy to understand.

The terminology promulgated here will differ from current terminologies of various land management agencies. Managers and planners are cautioned, therefore, to review agency policy regarding fire management terminology before using the suggested terms in plans or other official documents.

## EVOLUTION OF WILDERNESS FIRE MANAGEMENT POLICY

### Wilderness Policy

The Wilderness Act<sup>1</sup> requires that lands designated as components of the National Wilderness Preservation System “be administered . . . in such manner as will leave them unimpaired for future use and enjoyment as wilderness, and so as to provide for the protection of these areas, the preservation of their wilderness character, and for the gathering and dissemination of information regarding their use and enjoyment as wilderness.” The act defines wilderness “. . . as an area where the earth and its community of life are untrammelled by man, where man himself is a visitor who does not remain.” An area of wilderness is further defined to mean in the act an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man’s work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least 5,000 acres (2 023 ha) of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value.

Fire is a natural force that has helped shape the character of much of the American wilderness. According to Heinselman (1978), full recognition of fire’s role “is only now pervading ecological theory, but it seems clear that many of the forest, grassland, and savanna ecosystems of the primeval American wilderness were fire dependent.” An ecosystem can be called fire dependent if periodic perturbations by fire are essential to the functioning of the system (Heinselman 1978). In such ecosystems “fire initiated and terminated vegetational

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<sup>1</sup>An Act to establish a National Wilderness Preservation System for the permanent good of the whole people, and for other purposes. Public Law 88-557, 88th Congress, S.4, September 3, 1964.

succession; controlled the age structure and species composition of the vegetation; produced the mosaic of vegetation types of the landscape; affected insect and plant pathogen populations; influenced nutrient cycles and energy flows; regulated the biotic productivity, diversity, and stability of the system; and determined the habitats available to wildlife" (Heinselman 1978).

## Fire Management

Federal land management agencies generally pursued a policy of total fire control at the time the Wilderness Act was enacted. Discovered fires were aggressively attacked and eventually contained and controlled under such a policy. The fire control policy was applied to all lands regardless of classification or primary use. The use of certain fire suppression equipment was, however, often regulated by agency policy in wilderness areas.

The apparent conflict between overall wilderness management direction and fire control objectives was recognized by land managers even though fire control was specifically authorized in the Wilderness Act. There occurred, in fact, a general recognition that fire control activities should, in large part, be dictated by land management objectives on all Federal lands. The policy of fire control gradually changed, therefore, to a policy of fire management (Moore 1974; DeBruin 1976; Kilgore 1976a; Turcott 1979). Several definitions of the term "fire management" have been proposed (Barney 1975; Simard 1976) and other definitions implied (Barrows 1974; Mutch 1977; Heinselman 1978). It is difficult to present a single authoritative definition of fire management because the term is routinely used in two different contexts: a land management philosophy and a land management activity. As a management philosophy, fire management suggests that fire, in an ecological sense as well as in a protective sense, should be considered when developing land and resource management objectives, and that fire-related activities should be designed to accomplish these objectives. As a land management activity, fire management includes all the tasks related to the inclusion of fire considerations in land and resource management plans, protecting forests and rangelands from unwanted fire, and the use of fire to accomplish management objectives.

## Wilderness Fire Management

Early manifestations of the emerging concept of fire management occurred in the National Parks and in National Forest wildernesses. The National Park Service, responding to direction from Leopold and others (1963) initiated a natural fire program at Sequoia and Kings Canyon National Parks in 1968 (Kilgore 1976b). In 1972, the Chief of the Forest Service approved the agency's first wilderness fire management plan, for a portion of the Selway-Bitterroot Wilderness (Mutch 1974). Wilderness fire management programs have grown steadily since their inception. By 1982, some 6,794,000 acres (2 749 532 ha) were included in natural fire programs in 34 National Parks. Between 1968 and 1981, more than 919 unscheduled (naturally ignited) prescribed fires were allowed to burn 133,967 acres (54 216 ha) of

parkland. In addition, 183,674 acres (74 333 ha) were treated by 846 scheduled (manager-ignited) prescribed fires (Kilgore 1983).

Wilderness fire management programs are also expanding on the National Forests. During the period 1972-81, some 8,574,577 acres (3 470 131 ha) were included in 33 approved fire management plans for the western National Forests (Regions 1-6). The total includes 5,785,703 acres (2 341 474 ha) of wilderness and 2,788,874 acres (1 128 657 ha) of nonclassified National Forest land. By the end of the 1981 fire season, 369 unscheduled fires had burned a total of 59,380 acres (24 031 ha) since 1972 (Kilgore 1983).

A complete listing of National Park Service-prescribed fire programs and National Forest wilderness fire programs is included in appendix A.

## DEFINITION

Wilderness fire management is defined as follows:

**Wilderness fire management is the deliberate response to and use of fire through the execution of technically sound plans under specific prescriptions for the purpose of achieving stated wilderness management objectives.**

This definition places no preconditions on the practice of fire management. It is meant to encompass all fire-related plans and actions. Often, wilderness fire management is defined only in terms of the reintroduction of fire. Reintroduction implies absence for a period long enough to have become inoperative.

The prior absence or successful exclusion of fire is not recognized as a requirement for wilderness fire management in this report. Some of the legitimate objectives of wilderness fire management are not necessarily related to the prior occurrence and frequency of fire. Examples are visitor safety, protection of private property, boundary considerations, endangered species protection, and habitat management. Also, few wildernesses have experienced total fire exclusion for ecologically significant periods of time. Effective fire control has existed for less than 80 years, a timespan well within the natural fire-free interval of many wilderness vegetation types. Even the most aggressive fire control programs have had notable failures. Many of the fires that have started during periods of very high and extreme fire danger have escaped initial attack and have burned large acreages as fast-spreading, high-intensity, stand-destroying fires. Successful fire control has undoubtedly reduced the acreage burned in many wilderness areas, especially during the past several decades of high-technology fire control. Perhaps the most significant impact of successful fire control has been the nearly total elimination of the easy-to-suppress, slow-spreading, low-intensity surface fire. The vegetative mosaics that resulted over large areas when such fires periodically flared up, ran, and dropped back to the ground in response to changes in weather, topography, and fuel, are generally considered vital to the ecologic integrity of most wilderness ecosystems.

Wilderness fire management is often defined in terms of naturally fire-dependent ecosystems. It is essential that fire-dependent ecosystems be identified and that

wilderness fire management plans reflect such situations where they occur. Wilderness fire management plans can, however, be written for ecosystems that are not fire dependent. Wilderness fire management is an appropriate activity in any wilderness where fire occurs. There are legitimate objectives for wilderness fire management other than the maintenance of fire-dependent ecosystems—for example, the protection from fire of vegetation that is not ecologically dependent on periodic fire.

## IMPLICATION

The foregoing definition of wilderness fire management is a functional definition. It relates to the important tasks associated with the practice of wilderness fire management: responding to fire, using fire, and executing plans to achieve wilderness objectives. Many wilderness management objectives were achieved by the former practice of fire control. What, then, distinguishes wilderness fire management from wilderness fire control? One answer to this question might be that fire management implies cost effectiveness; that is, the cost of putting a fire out ought not exceed the value of the resources being protected. This is a valid distinction for lands managed for forest products where market prices can be used to evaluate the resource being protected. It does not adequately explain the difference between fire management and fire control for park and wilderness lands. The difference, according to Van Wagner and Methven (1980), is that wilderness fire management implies vegetation management.

It is important to realize that wilderness fire management is in fact vegetation management. It requires, as Van Wagner and Methven (1980) suggest, a vegetation plan that must be ecologically compatible with what can be achieved by managing fire, either through its application or its exclusion. Wilderness fire management planners must decide what kind of vegetation and associated wildlife is to be maintained, enhanced, and discouraged in the planning area. Planners must then determine the kinds of fires and fire frequencies that will produce the desired vegetation. This is no small task. Nonvegetation-related considerations and constraints will usually result in compromise with the ecologically ideal situation. The ideal should, nonetheless, be described as a basis or reference point for wilderness fire management in a given park or wilderness area.

## RESPONSE TO FIRE

Wilderness fire management was defined previously as the **deliberate response** to and use of fire through the execution of technically sound plans under specific prescriptions for the purpose of achieving stated wilderness management objectives. A **deliberate response** to fire is a response that results from careful and thorough consideration of consequences. It is a planned response. There are three general ways to respond to a fire: ignore it, attack it, or allow it to burn according to a predetermined plan. Ignoring a fire, or just letting it burn, is nonmanagement; hence it is not an acceptable response.

Fire attack can be delayed, aggressive, or modified. **Delayed attack** means that attack does not immediately follow discovery. A fire that is discovered at night, for example, might not be attacked until daylight. Delayed attack, once it occurs, can be aggressive or modified. **Aggressive attack** immediately follows discovery and with force sufficient to effect control at the earliest possible time with minimum acreage burned. **Modified attack** is less than aggressive attack. Suppression forces, techniques, strategy, or some combination of these factors are less than those defined for aggressive attack. The "minimum total" concept applies here (USDI Fish and Wildlife Service 1977). For example, additional acres burned might be acceptable if one uses handtools rather than tractors to build fireline in a wilderness area. Delayed and modified attack, like aggressive attack, should be fast, energetic, thorough, and conducted with regard for personnel safety.

Differentiating between delayed, aggressive, and modified attack emphasizes the strategy of fire attack. Another approach is to emphasize fire attack tactics. Using this approach three different fire responses are available: confine, contain, and control (USDA Forest Service 1981a). To **confine** a fire means to restrict it within boundaries that are either predetermined (pre-attack planning) or determined during the fire. To **contain** a fire means to surround it with a fireline, or firelines if spot fires exist, for the purpose of checking the fire's spread. To **control** a fire means essentially to put it out. This involves fireline construction, burning out, cooling hot spots, and other actions that remove any threat of subsequent escape.

The final response to fire is allowing it to burn as a prescribed fire. Allowing a fire to burn according to a predetermined plan is synonymous with the deliberate use of fire because both actions result in a prescribed fire. A **prescribed fire** is any fire burning in a predetermined area under predetermined environmental conditions and behaving in a predetermined manner to accomplish a predetermined management objective. Ignition of a prescribed fire can be either scheduled or unscheduled. A **scheduled prescribed fire** is one ignited by the manager at a predetermined time. An **unscheduled prescribed fire** is one that is ignited as a result of an act of God or unauthorized human activity. The time of such ignition is not known in advance.

The terms "planned ignitions" and "unplanned ignitions" are used by many fire managers instead of scheduled and unscheduled prescribed fires. A planned ignition is defined as a fire started by a deliberate management action, whereas an unplanned ignition is defined as a fire started at random by either natural or human causes. The problem with this terminology is that it implies, for example, that a lightning-caused fire allowed to burn under prescription is unplanned. The fact that a prescription exists, under which the fire is burning, contradicts such an implication. The fire in the above example is, in fact, planned (intended, anticipated, expected). Its exact time and place of occurrence are, however, not known in advance, hence the fire is unscheduled. A basic premise in this report is that all prescribed fires, by definition, are planned.

A prescribed fire can, then, be simply defined as any fire that is burning according to prescription. A prescription is a written direction for the use of a therapeutic or corrective agent. A **fire prescription** is, therefore, a **written direction for the use of fire to treat a specific piece of land**. The directions contained in a fire prescription consist of predesignated criteria that distinguish a prescribed fire from a wildfire.

A **wildfire** is any fire that is not a prescribed fire. It is an unwanted fire. A prescribed fire that deviates irreversibly from prescribed conditions (escapes prescription and cannot be quickly brought back into prescription) becomes a wildfire (also called an escaped fire, see below). Fires that receive delayed or modified attack are wildfires, not prescribed fires.

Wildfires that cannot be successfully controlled by initial attack forces, and prescribed fires that escape prescription and burn as wildfires, are called **escaped fires**. Subsequent action on such fires is based on a plan of action developed as a result of analysis of alternative suppression strategies. An alternative is selected on the basis of total cost effectiveness, public safety, probability of success, protection of property, and the effects of fire and fire suppression on the resources. The results of such **escaped fire analysis** or **situation analysis** are not prescriptions and should not be considered as such. The fire, regardless of management action taken following escaped fire analysis, remains a wildfire.

In the case of an escaped prescribed fire, the decision may be to take the limited suppression action necessary to bring the fire back into prescription. If such action is successful, the fire may regain prescribed fire status since it would again meet the definition of a prescribed fire.

## NATURAL VERSUS HUMAN IGNITIONS

The type of ignitions appropriate to achieve fire management objectives should be identified during planning. Wilderness has, of course, an esthetic, spiritual dimension. This is reflected in management policies that place strong emphasis on allowing natural process to function while discouraging or prohibiting the use of anything unnatural. Consequently, wilderness management policies generally encourage the prescribed use of natural ignition agents, such as lightning and volcanic eruptions, to accomplish wilderness fire management objectives and generally discourage or prohibit the prescribed use of unauthorized human ignitions (accidental man-caused fires).

Van Wagner and Methven (1980) make a strong argument for the irrelevancy of mode of ignition. They reason that the effect of any fire is quite independent of how it started; the forest, they point out, certainly cannot tell the difference. They suggest that the only worthwhile distinction is between wanted and unwanted fire as determined by management objectives.

Heinselman (1978) cites concern about safety and concern about unnatural ecosystem effects due to prior fire exclusion as the only legitimate reasons for using scheduled prescribed fires. Safety concerns, according to Heinselman (1978), might dictate that only scheduled prescribed fires **"be used near the wilderness perimeter,**

**near enclaves of development, in very small wilderness in high visitor use areas, and in ecosystems where it is known that natural fires tend to be high-intensity crown fires or severe and fast-moving surface fires."** Such situations exist in many National Park and National Monument wilderness-type areas. An example of unnatural ecosystem effects due to prolonged fire exclusion would be the situation where unnaturally large fuel accumulations occur in forest stands that experience only low intensity surface fires under a natural fire regime. Unnaturally heavy fuel accumulations can make such stands susceptible to stand-destroying crown fires. Scheduled prescribed fires during moderate burning conditions can reduce fuel accumulations so that subsequent unscheduled ignitions can more nearly play their natural role.

Because parks and wilderness areas are surrounded by boundaries that separate them from areas of different uses, are of limited area, and because their visitors must be protected from uncontrolled fire, a totally natural fire regime is neither possible nor desirable according to Van Wagner and Methven (1980). The objective of perpetuating certain ecosystems within parks and wilderness areas would, they suggest, have to be met by a planned fire regime, probably involving scheduled as well as unscheduled fire. Van Wagner and Methven (1980) feel that the renewal rates and fire cycles would best be set according to the ecology and longevity of the main species, in conjunction with the present age-class distribution and the evidence of fire history. They readily admit that actual locations, numbers, and sizes of fires would be subject to many practical considerations.

Lack of defensible boundaries and typical fire behavior favor the use of scheduled rather than unscheduled prescribed fires to accomplish wilderness fire management objectives in certain northern ecosystems. Alexander and Dube' (1983) cite the example of northern ecosystems characterized by generally flat terrain with continuous fuels, where fires are most often stand-replacing, high-intensity surface or crown fires that defy containment or confinement.

A final situation that often warrants consideration of scheduled versus unscheduled ignitions is the wilderness area traditionally swept by fire originating from a point now outside the wilderness boundary. Fires are now suppressed in the developed lower lying areas that surround many small, high-elevation wildernesses, thereby effectively eliminating any chance of reestablishing a natural fire regime.

Management policies regarding the use of fire to accomplish wilderness fire management objectives are important criteria for planning. Wilderness managers should be aware of these policies before attempting to develop wilderness fire management plans.

## PLANNING CONCEPTS

### Planning Area

The ideal fire management planning area has distinct topographic boundaries within which any free-burning fire would be naturally contained. The logical planning area for wilderness fire management is the designated



wilderness, National Park, National Monument, or wildlife refuge. Wilderness boundaries often, however, reflect political rather than topographic considerations. Many wilderness boundaries consequently are less than ideal for fire management planning.

There are several ways to deal with unfavorable boundary situations. The planning area boundary can be set at favorable topographic, vegetative, or fuel situations nearest to the wilderness boundary. This solution might require that some nonwilderness lands be included within the planning area, or that some wilderness lands be excluded from the planning area, or both. This approach may not be acceptable for certain areas. Another solution is to have the planning area and wilderness boundaries coincide and deal with unfavorable boundary situations when designating fire management units and writing fire management prescriptions. This latter approach is the one most often used, but in certain situations the first approach can simplify fire management planning. A third approach is to establish a fuel break around the area. This approach might be practical when the wilderness is small and the fire break is compatible with adjoining wilderness values.

Separate fire management plans are sometimes written for a portion of a wilderness. This may be a practical approach in very large wildernesses that include several topographically distinct portions or when separate portions of a wilderness are managed by different administrative units. Such piecemeal or stepwise planning should be governed by an overall plan developed by all responsible parties to insure uniform methods, comparable prescriptions, and coordinated fire management over the entire wilderness.

A final consideration regarding the planning area relates to the use of the term "fire management area." A **fire management area** is defined as **one or more parcels of land with common fire management objectives** (USDA Forest Service 1978a). This term is being used in two different ways. In some cases it is used to mean the planning area, for example, the Selway-Bitterroot Wilderness Fire Management Area. In other cases, the term fire management area is used to identify portions of the planning area for which specific fire management prescriptions have been written. In many plans, however, such portions of the planning area are labeled fire management units or zones. In this report, the term "fire management area" refers to the planning area. Delineation of fire management units and zones is discussed in a following section on planning elements.

## Planning Context

Wilderness fire management plans cannot be developed in a vacuum. The actions of land management agencies are governed by laws, executive orders, and regulations. The agencies, in turn, formulate policies that further govern the actions of their agents. Many of these laws, regulations, and policies affect wilderness management, fire management, and land management planning. Wilderness fire management plans must reflect the intent of such influences.

## PLANNING HIERARCHY

In most land management agencies planning requirements result in a hierarchy of plans. Plans range from broad, national-level documents, to plans that prescribe specific actions on a specific piece of land. The wilderness fire management plan falls at the lower end of the planning hierarchy. As such, it must respond to direction contained in the next higher level plan. This is an important point. Wilderness fire management planners must assure that wilderness fire management issues are properly identified and that contemplated actions are authorized at all appropriate levels of planning.

Wilderness fire management planning for Federal lands is subject to the requirements of the National Environmental Policy Act (NEPA) of 1969 (Public Law 91-190). NEPA requires that a systematic interdisciplinary approach be used in planning and decision-making that may affect the human environment. The relationship between NEPA requirements and wilderness fire management planning is illustrated using the Forest Service NEPA process as an example (USDA Forest Service 1981b).

## DEVELOPING A FIRE MANAGEMENT PLAN USING THE NEPA PROCESS<sup>2</sup>

The fire management plan is developed using guidance contained in existing multiple-use plans, unit plans, forest land management plans, wilderness management plans, and regional guides, as follows:

### NEPA Process Outline

1. Environmental analysis
  - A. Identify issues, concerns, opportunities
  - B. Develop criteria
  - C. Data collection
  - D. Analyze the situation
  - E. Formulate alternatives
  - F. Estimate effects
  - G. Evaluate alternatives
  - H. Identify preferred alternative
2. Documentation
3. Decision
4. Implement and monitor

These are activities the interdisciplinary team, specialists, and line and staff managers will be involved with in developing the environmental assessment for the wilderness fire management plan. The results of the environmental assessment are documented, usually using the standard Council of Environmental Quality (CEQ) format:

### Standard CEQ Format

- A. Cover sheet
- B. Summary
- C. Table of contents
- D. Purpose of and need for action
- E. Alternatives

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<sup>2</sup>This section was written by Hugh G. Pangman, Land and Resource Planning Group, Intermountain Region, USDA Forest Service, Ogden, Utah, personal communication, July 1981.



F. Environmental consequences

G. List of agencies, organizations, and persons to whom copies of the document are sent

H. Index

I. Appendix

Other formats useful for planning and decisionmaking may be used, but they must include discussions of items D, E, F, and G of the standard format. The NEPA process outline should not be confused with the CEQ standard format. The NEPA process outline lists the activities involved in an environmental assessment. The CEQ standard format is the format for documenting the results of the assessment. The results of the assessment are documented to show the analytical procedures, considerations, and rationale in arriving at a decision—in this case, the preferred fire management alternative. The wilderness fire management plan is separate from the environmental assessment document, although some information may be taken from the assessment for use in the plan. The information used to select the preferred alternative should, for example, be useful for developing appropriate wilderness fire management prescriptions.

The data requirements for the NEPA process and wilderness fire management plan need not be handled separately. Requirements for each can often be handled simultaneously. As data are gathered, it is necessary to reevaluate preliminary information on objectives, issues, alternatives, and criteria, making additions and refinements as needed.

Key NEPA process requirements and how they relate to the requirements for wilderness fire management planning are discussed below.

### **Establishing Scope of the Study**

The initial phase of planning is devoted to determining the scope of the study. This process is called "scoping" in the jargon of Forest Service planners (USDA Forest

Service 1981b). Both NEPA and fire planning requirements are assessed to assure proper data collection and evaluation at the outset. Some major considerations are:

**Objectives.**—The land management and wilderness management objectives that will guide fire management planning. The management objectives for the area.

**Preliminary alternatives.**—Fire management prescriptions for different units within the wilderness. (These are general considerations at this point and are refined as data are collected and evaluated.)

**Data collection.**—This is concerned with two types of data:

1. Data necessary to evaluate fire management alternatives and to complete the fire management plan.

2. Environmental concerns and public involvement (fig. 1).

The scoping system results in a plan to complete the NEPA process and the wilderness fire management plan.

Other requirements of the NEPA process are contained in agency guidelines and are not repeated here. The intent is to show how NEPA and the fire management plan are interrelated. The environmental assessment is completed before the wilderness fire management plan, although portions of the latter will be completed concurrently. The depth of the environmental assessment will be governed by the complexity of the wilderness being studied and the issues involved, and whether an environmental impact statement is needed. A concept labeled "tiering" (USDA Forest Service 1981b) is relevant here. Essentially, tiering means that general matters covered in environmental impact statements for broad plans can be referenced in subsequent statements for narrower plans. Hence, for example, a discussion of fire management policies included in an environmental statement for a National Forest plan can be referenced rather than repeated in a wilderness fire management plan, environmental statement, or assessment.

## CHECKLIST OF ENVIRONMENTAL AND PUBLIC INVOLVEMENT FACTORS

\_\_\_\_\_  
(Name of Action/Proposal)

The following key describes the disposition of the listed factors:

- D. Discussed in assessment.
- C. Considered in analysis; no further discussion deemed necessary.

### Physical environment

1. \_\_\_\_ Geologic hazard
2. \_\_\_\_ Climatic
3. a. \_\_\_\_ Soil productivity  
b. \_\_\_\_ Capability  
c. \_\_\_\_ Erodibility of soils  
d. \_\_\_\_ Mass failure
4. a. \_\_\_\_ Locatable minerals  
b. \_\_\_\_ Leasable minerals  
c. \_\_\_\_ Energy sources
5. \_\_\_\_ Visual resource
6. a. \_\_\_\_ Archaeological resources  
b. \_\_\_\_ Historical resources  
c. \_\_\_\_ Architectural resources
7. \_\_\_\_ Wilderness resources
8. a. \_\_\_\_ Water quality  
b. \_\_\_\_ Streamflow regimes  
c. \_\_\_\_ Flood plains  
d. \_\_\_\_ Wetlands  
e. \_\_\_\_ Ground water recharge  
f. \_\_\_\_ Water rights
9. \_\_\_\_ Air quality
10. \_\_\_\_ Noise
11. a. \_\_\_\_ Potential wildfire hazard  
b. \_\_\_\_ Role of fire in ecosystem

12. \_\_\_\_ Land uses (includes prime farmlands)
13. a. \_\_\_\_ Roads  
b. \_\_\_\_ Trails  
c. \_\_\_\_ Electrical transmissions  
d. \_\_\_\_ Communications systems  
e. \_\_\_\_ Solid waste management  
f. \_\_\_\_ Sanitary waste  
g. \_\_\_\_ Rights-of-way  
h. \_\_\_\_ Land line

### Biological factors

14. a. \_\_\_\_ Forest (includes diversity)  
b. \_\_\_\_ Rangeland management  
c. \_\_\_\_ T and E plants  
d. \_\_\_\_ Other vegetation types  
e. \_\_\_\_ Research natural areas potential  
f. \_\_\_\_ Unique ecosystems (other than RNA)
15. a. \_\_\_\_ Wildlife population  
b. \_\_\_\_ Habitat  
c. \_\_\_\_ T and E species  
d. \_\_\_\_ Diversity of animal communities
16. a. \_\_\_\_ Fisheries habitat  
b. \_\_\_\_ Population  
c. \_\_\_\_ T and E species
17. \_\_\_\_ Outdoor recreation resources
18. \_\_\_\_ Economic base

(con.)

Figure 1.—Environmental and public involvement assessment checklist for identifying issues, concerns, and management opportunities.

## CHECKLIST OF ENVIRONMENTAL AND PUBLIC INVOLVEMENT FACTOR (con.)

### Economic and social factors

- 19. \_\_\_\_ Employment/unemployment
- 20. \_\_\_\_ Housing
- 21. \_\_\_\_ Land use requirements
- 22. \_\_\_\_ Community service requirements
- 23. a. \_\_\_\_ Local government base  
b. \_\_\_\_ Special service districts base
- 24. \_\_\_\_ Plans and programs of other agencies
- 25. a. \_\_\_\_ Income sources  
b. \_\_\_\_ Income accounts  
c. \_\_\_\_ Income distribution
- 26. a. \_\_\_\_ Population numbers  
b. \_\_\_\_ Minority composition  
c. \_\_\_\_ Distribution and density
- 27. \_\_\_\_ Civil rights
- 28. \_\_\_\_ Local cultures
- 29. \_\_\_\_ Personal security
- 30. \_\_\_\_ Education, cultures, and recreation opportunity
- 31. \_\_\_\_ Legal considerations
- 32. \_\_\_\_ Rights-of-way
- 33. \_\_\_\_ Land line

### Public involvement

Attach a list of Federal, State, and local agencies, individuals and organizations interested or involved in the proposal, or having information or expertise relative to the project.

Conducted by: \_\_\_\_\_  
Name(s)  
\_\_\_\_\_  
Date

Approved by: \_\_\_\_\_  
Name and Title  
\_\_\_\_\_  
Date

Figure 1.—(con.)

## The Plan

The purpose of wilderness fire management planning is to produce a wilderness fire management plan that reflects management direction for the park or wilderness area. A plan is a detailed formulation (systematized statement) of a program of action. The wilderness fire management plan is, therefore, the primary guide for all fire management actions within the planning area, including response to wildfire and the conduct of prescribed fires.

Wilderness fire management plans usually must be reviewed and approved by those not involved in their development. The rationale for the planned actions must, therefore, be documented. Such documentation is best done in a separate report or in associated environmental assessments or environmental impact statements. If the plan and the supporting rationale are presented in one report, the plan should be a separate and distinct part.

## FORMAT

The format of wilderness fire management plans is governed by agency requirements, complexity of planned actions, and the creativity of the planner. The important consideration is that the plan be complete, concise, and easy to use.

## CONTENT

A wilderness fire management plan should include the following four parts:

1. A brief introduction in which related plans and supporting documents are identified,
2. Explicit fire management objectives,
3. A map of the fire management area, with fire management units and zones clearly delineated and identified, and
4. Planned actions (what, when, who, and if appropriate, how) for:
  - a. Responding to fire starts,
  - b. Suppressing wildfires,
  - c. Analyzing escaped fires,
  - d. Monitoring prescribed fires,
  - e. Igniting and conducting prescribed fires,
  - f. Evaluating fire effects,
  - g. Preventing unwanted fires,
  - h. Presuppression activities,
  - i. Protecting visitors from fire injury,
  - j. Informing and involving the public,
  - k. Notifying appropriate individuals and agencies and reporting fire actions and activities, and
  - l. Reviewing and revising the plan.

## WHAT IS AN ADEQUATE PLAN?

Wilderness ecosystems vary in ecological complexity, environmental stability, and fire potential. Agency policy, user patterns and concerns, as well as management direction and opportunities, vary from area to area. All these factors and others determine the adequacy or scope of the wilderness fire management plan.

The environmental analysis should provide a basis for determining the depth or complexity of the planning

effort and the resulting plan. The scoping process indicated earlier integrates public participation and coordination, document research and administrative activities and provides a foundation for environmental analysis. The idea is to provide a means for identifying issues early in the NEPA decisionmaking process to ensure thorough analysis and determine the scope or extent of the analysis (USDA Forest Service 1981b).

## PLANNING ELEMENTS

Wilderness fire management planning can be separated into six essential elements:

1. Describing fire and ecosystem interactions.
2. Describing special resource and use considerations.
3. Defining fire management objectives.
4. Delineating fire management units and zones.
5. Developing fire management prescriptions.
6. Devising a fire management plan.

The elements are listed in a proper sequence for planning and each depends in part on information developed earlier in the planning sequence. Prescription evaluation and plan revision are not listed as planning elements because they occur after the initial plan has been developed and implemented. These are, however, important elements of the fire management plan. Public involvement is an important part of planning. It is not listed above because it is assumed here that public involvement will occur as part of the environmental analysis process. Subsequent actions directed at public information and involvement are elements of the fire management plan.

Each of the above listed planning elements is defined and discussed in terms of planning approach, information needs, and method of presentation. Selected references to aid wilderness fire management planning are listed in appendix B.

## Fire and Ecosystem Interactions

The first step in wilderness fire management planning is to describe how the physical and biological characteristics of planning area ecosystems have been and might be affected by fire, the absence of fire, and fire suppression actions. Interactions between fire and other ecosystem components can be identified by delineating and describing planning area ecosystems in relation to their fire situation. Consider this to be a three-step process: (1) classify, describe, and map area ecosystems; (2) describe the fire situation; and (3) identify and describe significant fire-related interactions. (In practice these three steps may not be so clear cut.)

## ECOSYSTEM CLASSIFICATION

Classification involves grouping similar objects and separating dissimilar objects. Classification brings order to our thinking and communication by systematically naming the objects being classified and showing the relationships among them. The purpose of classification for land management is to organize, communicate, and collect information for decisionmaking.

Identification and delineation of wilderness ecosystems is important because such classification provides (1) a basis for inventorying current resources, (2) a means of transferring experience and knowledge about a studied area to a similar but unstudied area, (3) a framework for assessing local management opportunities and predicting the outcomes of treatments or actions, and (4) a means for communicating among managers, researchers, and the public (Frayser and others 1978).

Ecosystem classification terminology, methods, and approaches are reviewed and evaluated by Pfister (1977) and Bailey and others (1978). Another useful reference is the Guide to Land Cover and Use Classification Systems employed by western governmental agencies (Ellis and others 1977). Additional references are listed in appendix B.

## INTEGRATED CLASSIFICATION SYSTEMS

Wilderness fire management planning needs are best served by an integrated approach to ecosystem classification. Enlightened decisions relating to fire use, fire exclusion, and fire control require knowledge of soils, current and potential vegetation, and landform. A fourth component, water, may be equally important in many wilderness areas. According to Driscoll (1980), agency leaders of the Bureau of Land Management, Fish and Wildlife Service, Forest Service, Geological Survey, and Soil Conservation Service endorsed a four-component classification system to be used for renewable resource inventories and assessments (Driscoll and others 1978). The hierarchical components are vegetation, soil, landform, and aquatic (water).

The major four-component ecosystem classifications described in the literature are biophysical land classification (Lacate 1969), ECOCLASS (Corliss and others 1973), modified ECOCLASS (Buttery 1978), and ECOSYM (Henderson and others 1979). To date, none of these classifications have been used in conjunction with wilderness fire management planning efforts. This is mostly due to the still developmental nature of the systems.

Ecosystem classification based on integration of three components has been and is being used for wilderness fire management planning in the Forest Service Northern Region. The Clearwater National Forest portion of the Selway-Bitterroot Wilderness was, for example, stratified into ecological land units (ELU's) as a first step in fire management planning (Fiman and Thomas 1979). An ELU is defined as an identifiable parcel of land having similar characteristics of landform, soils, and potential vegetation. The ELU in this example is comparable to the land type association (LTA) of the Land Systems Inventory (Wertz and Arnold 1972; Wendt and others 1975; USDA Forest Service 1976). The land system is outlined in figure 2.

A recent land system inventory of the Scapegoat and Danaher portion of the Bob Marshall Wilderness (Flathead, Lolo, Lewis and Clark, and Helena National Forests) in Montana is another example of the application of the land system for wilderness fire management planning (Holdorf and others 1980). Figure 3 is a land type association (LTA) map developed for a portion of the planning area. Land type associations are based on

associations of habitat types, soils, and landforms (see fig. 2). Mapping units are designed to produce analysis units with similar response to wilderness management. The principal management practice considered is fire management, but properties influencing wildlife habitat, watershed behavior, and wilderness recreation were also considered.

## THE FIRE SITUATION

The second step in defining interactions between fire and other ecosystem components is to describe the fire situation for the planning area. "Fire situation" is an arbitrary term used here to identify fire's historic role, the current potential for fire, and the probable effect of present and future fire on planning area ecosystems.

## FIRE HISTORY

A requirement of wilderness management is to preserve natural conditions. The wilderness fire management planner must therefore understand the role played by fire, if any, in establishing and perpetuating natural conditions. The planner must also determine the probable effect, if any, of past fire exclusion. To understand the role fire has played, planners must determine the fire history of the planning area.

### Postglacial Period

Methods for investigating fire history vary according to the time periods of interest. Evidence of fire and its role in determining the composition of forest vegetation during the period following the retreat of glaciers in northern and mountain regions of North America can be obtained from lake and bog sediment cores (Swain 1973; Mehringer and others 1977; Schweger 1978). Wilderness fire management planners rarely have the resources to conduct studies of this type. They should, however, review the ecological, paleoecological, paleobotanical, geological, and related literature for studies that might pertain to planning area ecosystems.

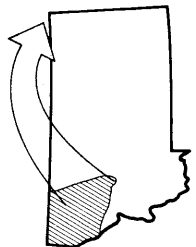
### Settlement Period

Journals of early explorers and settlers and investigations of aboriginal fire practices are important sources of fire history. Examples of such sources are Lutz (1959) for Alaska, Reynolds (1959) and Kilgore and Taylor (1979) for the Sierra Nevada region, Lewis (1977, 1978) for northern Alberta, Barrett (1980a, 1980b) for the Northern Rockies, and Shinn (1980) for the inland Pacific Northwest. Such information is usually not detailed enough to develop a fire history for a specific area. The use of early government land survey records to estimate the proportion of stands killed by fire in a 15- to 25-year period preceding the survey for vast areas of presettlement forest is discussed by Lorimer (1980).

Many investigators have developed detailed fire histories dating back to A.D. 1700 or earlier, which actually predates settlement in many areas. The investigators used historical records and techniques for reading tree rings and determining stand origin analysis. Heinzelman (1973) describes these techniques and cites their use in developing a fire history for the Boundary Waters Wilderness.

# THE LAND SYSTEM

ONTARIO PORTION  
NORTHERN ROCKY MOUNTAIN  
FOREST  
TYPE



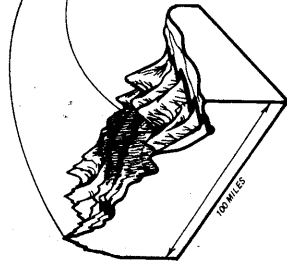
## PROVINCE

**Definitive Criteria:** Basic Components -  
Lithology, Structure, Climate-Vegetation  
Belongness regional differences by topographic  
position and climatic conditions as expressed by broad  
vegetative patterns

**Mapping Scale:** 1:1,000,000 on larger  
Scale: 1:975,000 to 1:200,000  
Size: 1075 sq. miles  
Use: National Forest Planning & Policy  
Summary

**LOCATION:** NORTHERN PORTION OF THE NORTHERN  
DIVISION  
Geomorphic Processes: Uplift, Alpine  
Glaciation, Fluvial  
Topography: Mountain and Intermountain Valleys  
Soils: Entisols, Inceptisols, Alfisols and  
Spodosols  
Vegetation: Coniferous Forest

**Major Qualities:** High water production, timber  
and habitat for wildlife & fisheries, mining  
& recreation



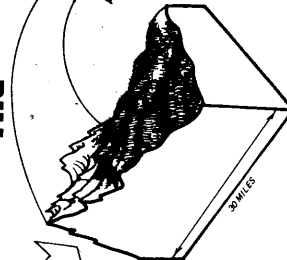
## SECTION

**Definitive Criteria:** Basic Components -  
Lithology, Structure, Climate-Vegetation  
Belongness regional differences by topographic  
position and climatic conditions as expressed by broad  
vegetative patterns

**Mapping Scale:** 1:500,000 - 1:1,000,000  
Scale: 1:475,000 to 1:200,000  
Size: 1075 sq. miles  
Use: National Forest Planning & Policy  
Summary

**LOCATION:** NORTHERN PORTION OF THE NORTHERN  
DIVISION  
Geomorphic Processes: Alpine Glaciation  
Topography: High Mountain Ranges  
Soils: Entisols, Inceptisols, Alfisols and  
Spodosols  
Vegetation: Alpine Fir and White Birch Pine

**Major Qualities:** High water production, good  
habitat for wildlife & fisheries, important  
recreation areas



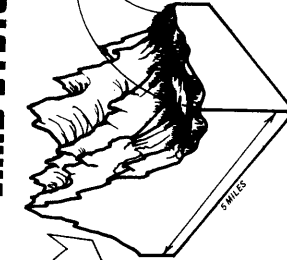
## SUBSECTION

**Definitive Criteria:** Basic Components -  
Lithology, Structure, Climate-Vegetation  
Belongness regional differences by topographic  
position and climatic conditions as expressed by broad  
vegetative patterns

**Mapping Scale:** 1:500,000 - 1:1,000,000  
Scale: 1:475,000 to 1:200,000  
Size: 1075 sq. miles  
Use: National Forest Planning & Policy  
Summary

**LOCATION:** NORTHERN PORTION OF THE NORTHERN  
DIVISION  
Geomorphic Processes: Alpine Glaciation and  
Topography: High Mountain Ranges  
Soils: Entisols, Inceptisols, Alfisols and  
Spodosols  
Vegetation: Alpine Fir and White Birch Pine

**Major Qualities:** High water production, good  
habitat for wildlife & fisheries, important  
recreation areas



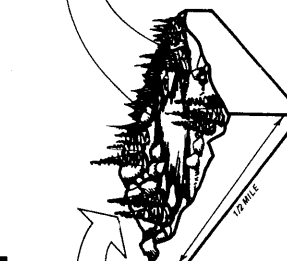
## LANDTYPE ASSOCIATION

**Definitive Criteria:** Basic Components -  
Lithology, Structure, Climate-Vegetation  
Belongness regional differences by topographic  
position and climatic conditions as expressed by broad  
vegetative patterns

**Mapping Scale:** 1:500,000 - 1:1,000,000  
Scale: 1:475,000 to 1:200,000  
Size: 1075 sq. miles  
Use: National Forest Planning & Policy  
Summary

**LOCATION:** NORTHERN PORTION OF THE NORTHERN  
DIVISION  
Geomorphic Processes: Alpine Glaciation, about  
Topography: High Mountain Ranges  
Soils: Entisols, Inceptisols, Alfisols and  
Spodosols  
Vegetation: Alpine Fir and White Birch Pine

**Major Qualities:** High water production, good  
habitat for wildlife & fisheries, important  
recreation areas



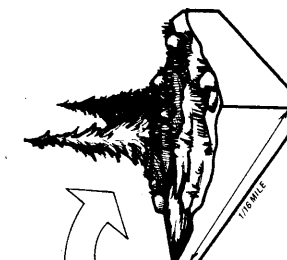
## LANDTYPE

**Definitive Criteria:** Basic Components -  
Lithology, Structure, Climate-Vegetation  
Belongness regional differences by topographic  
position and climatic conditions as expressed by broad  
vegetative patterns

**Mapping Scale:** 1:500,000 - 1:1,000,000  
Scale: 1:475,000 to 1:200,000  
Size: 1075 sq. miles  
Use: National Forest Planning & Policy  
Summary

**LOCATION:** NORTHERN PORTION OF THE NORTHERN  
DIVISION  
Geomorphic Processes: Alpine Glaciation, about  
Topography: High Mountain Ranges  
Soils: Entisols, Inceptisols, Alfisols and  
Spodosols  
Vegetation: Alpine Fir and White Birch Pine

**Major Qualities:** High water production, good  
habitat for wildlife & fisheries, important  
recreation areas



## LANDTYPE PHASE

**Definitive Criteria:** Basic Components -  
Lithology, Structure, Climate-Vegetation  
Belongness regional differences by topographic  
position and climatic conditions as expressed by broad  
vegetative patterns

**Mapping Scale:** 1:500,000 - 1:1,000,000  
Scale: 1:475,000 to 1:200,000  
Size: 1075 sq. miles  
Use: National Forest Planning & Policy  
Summary

**LOCATION:** NORTHERN PORTION OF THE NORTHERN  
DIVISION  
Geomorphic Processes: Alpine Glaciation, about  
Topography: High Mountain Ranges  
Soils: Entisols, Inceptisols, Alfisols and  
Spodosols  
Vegetation: Alpine Fir and White Birch Pine

**Major Qualities:** High water production, good  
habitat for wildlife & fisheries, important  
recreation areas

Adapted from the  
Northern Forest  
Inventory  
Report 1975

Figure 2.—The land system (sources: USDA Forest Service 1976; Wendt and others 1975).



Figure 3.—Land type association map for a portion of the Scapegoat and Bob Marshall Wilderness areas, Flathead, Lolo, and Lewis and Clark National Forests (source: Holdorf and others 1980). Land types are: I, forested flood plains; Ia, wet, grass-sedge meadows; Ib, grass and forested stream terraces; II, glacial cirque basins; III, forested ground moraine; IIIa, forested steep lateral moraine; IV, slump land; Va, forested high elevation ridges; Vb, forested smooth residual slopes; Vc, forested moderately dissected residual slopes; Vd, forested and grassland smooth residual slopes; VI, peaks and alpine ridges—sparsely vegetated rock land; VII, forested, cool aspect break lands; VIII, forested, warm aspect break lands.

LAND TYPE ASSOCIATION MAP  
DANAHER-SCAPE GOAT AREA  
USFS REGION 1  
SCALE: 1:63,360 MAY 1979



Arno and Sneek (Davis) (1977) describe a step-by-step method for determining fire history in coniferous forests of the Mountain West. This method is designed to answer the following questions: What were the (1) average, minimum, and maximum intervals between fires in various forest habitat; (2) sizes and intensities of fires; (3) effects of past fire on forest vegetation, particularly stand composition and age class structure; (4) effects of modern fire suppression? Arno and Sneek (Davis) (1977) provide instructions for study area selection, field reconnaissance, sampling fire-scarred trees, and analysis of fire scars and stand data.

Alexander (1979, 1980) and Mastrogioseppe and others (1983) have developed and maintained a bibliography of fire history studies. This bibliography is a useful source for identifying available fire history information in North America.

### Fire Control Period

Most fires that have occurred since the advent of organized fire control are documented. These fire reports are the major source of fire history information for the period starting about 1900. Maps showing fire locations and the boundaries of large fires that have occurred during the past 80 to 100 years are maintained by some fire control agencies as part of periodic fire planning. These maps are excellent sources of fire history information.

Fire history techniques and fire histories for specific parks and wilderness areas are referenced in appendix B.

### FIRE POTENTIAL

Fire potential is an ecosystem's capability for fire. The traditional concepts of fire risk, fire hazard, and fire danger are incorporated within the concept of fire potential. The important determinants of fire potential are probable fire occurrence, the fire environment, and probable fire behavior. Fire environment refers to the conditions, influences, and modifying forces that control fire behavior (Countryman 1972). The fire environment is composed of three interacting influences: fuels, weather, and topography.

### Fire Occurrence

Probable fire occurrence is, for lack of a better method, usually based on past fire occurrence. Individual fire reports are the primary source of information on past fire occurrence. Most fire control agencies have such reports for all known fires since the early 1900's. Regionwide summaries of fire occurrence for wilderness areas, primitive areas, and wilderness study areas in the Northern Rocky Mountains and in the Southwest are presented by Barrows and others (1977) and by Barrows (1978, 1979).

A useful expression of lightning fire occurrence is lightning fire density (fires per million acres per year; fires per km<sup>2</sup>/year) by such ecosystem characteristics as cover type and elevation. Fire density values should be derived using the normalizing technique suggested by Bevins and Barney (1980) and Bevins and Jeske (1978).

Stocks and Hartley (1979) summarized fire occurrence data for Ontario. Their summary includes probability of

fires occurring under different levels of fire danger and a map showing fire densities.

Man-caused fire probabilities are more difficult to determine than are lightning fire probabilities. Past occurrence patterns are relevant but are sensitive to fire prevention programs, trail construction and maintenance, and other such factors that affect people's actions and access.

Roussopoulos and others (1980) have developed a prototype National Fire Occurrence Data Library (NFODL). The NFODL facilitates nationally uniform editing, storage, retrieval, and analysis of wildland fire report data. It is maintained at the USDA Fort Collins Computer Center and now contains all USDA Forest Service Individual Fire Report data since 1970. Provisions have been made to accommodate data from other agencies. The NFODL can be a very useful aid for analyzing fire report data as a basis for predicting future occurrence patterns.

### Fire Environment

The fire environment is composed of three interacting influences: fuels, weather, and topography.

Topography includes such elements as slope, aspect, elevation, and configuration. Topography is an element of landform. Topographic information will, consequently, be available if landform analysis was performed as part of ecosystem classification. The primary sources of existing topographic information are aerial photos and topographic maps.

Alexander and Woods (1978) discuss many of the considerations involved in preparing a fire weather climatology for park- and wilderness-type areas. Weather elements influencing planning area ecosystems must be characterized using historic weather data. FIRE-FAMILY, a computer program that uses historic weather data to predict fireline fire management needs, can be a useful fire management planning tool (Main and others 1982). Wilderness fire planners should summarize weather and climatic data according to the guidelines presented by Finklin (1983).

Fuels occupying planning area ecosystems should be characterized in terms of kind, size, amount, location, and areal extent. Methods used should be consistent with desired precision, which in turn should depend on the cost or consequences of an incorrect fuel-related decision (Hamilton 1978). Methods for characterizing fuels include actual inventory, photoguides, known relationships from existing data, and fuel models.

Brown and others (1982) present procedures for inventorying living and dead surface vegetation.

Photoguides for estimating loadings of natural fuels have been developed for forest types in the Pacific Northwest (Maxwell and Ward 1980a, 1980b), for the Southern Cascades and Northern Sierra Nevada (Blonski and Schramel 1981), and for the Northern Rocky Mountains (Fischer 1981a, 1981b, 1981c, 1981d). Where applicable, the guides can be used to obtain reasonable estimates of fuel loads for less than the cost of fuel inventory. At the same time they provide visual references of fuel situations that can be used when deciding appropriate actions on fire starts.

Known relationships from existing fuel inventory data can be obtained for some forest types from a prototype National Fuels Inventory Library (NFIL) developed by Bevins and Roussopoulos (1980). This library is maintained at the USDA Fort Collins Computer Center.

Summaries and analyses of existing fuel inventory data for local areas have been published.

A final method for characterizing fuels is the use of fuel models. The most popular fuel models are those used with the NFDRS (Deeming and others 1977; Anderson 1982).

Albini (1976) cautions that the accuracy with which any particular situation in the field is reproduced by one of these stylized models is highly variable. A recent innovation that may reduce this variability is the BEHAVE computer system (Andrews 1983). BEHAVE provides a capability for trained field personnel to construct fuel models tailored to a site.

## Fire Behavior

Probable fire behavior depends on the likely interactions between elements of the various fire environments existing in the planning area. The first step in characterizing probable fire behavior is to identify planning area ecosystems that have similar topography and fuels. Ecosystems may also be stratified according to weather if such site-specific data are available. The next step is to estimate probable fire behavior for each ecosystem or group of ecosystems for the range of probable weather conditions, or for some specific benchmark weather condition.

Estimating probable fire behavior is a critical fire management planning task. It is also a demanding and relatively complex task. Rothermel (1983) has recently produced a manual in which he documents state-of-the-art procedures for estimating the rate of forward spread, intensity, flame length, and size of fires burning in forests and rangelands. Rothermel's procedures have become the generally accepted standard for wildland fire behavior prediction. Rothermel's procedures plus a capability of building site-specific fuel models are packaged in the BEHAVE computer system (Andrews 1983). Although neither system was designed for long-range planning, both can use expected weather or climatological data from an area that, when coupled with an assessment of the fuels and site conditions, can give appraisals of the expected fire behavior.

The National Fire-Danger Rating System (NFDRS) may also be used for planning wilderness fire potential and for monitoring fire potential as the season develops.

The NFDRS contains two components and an index that have been used for estimating potential fire behavior. The spread component (SC) integrates the effect of wind, slope, and fuel to predict the forward rate of fire spread. Fuel is characterized by fuel models. The energy release component (ERC) indicates the potential amount of energy that can be released in a passing fire. The ERC reflects the effect of fuel moisture on fire intensity. The SC and ERC combine in the NFDRS to form the burning index (BI). The BI is designed to be a measure of the difficulty of containing a single fire. The BI has been interpreted in terms of fire behavior, controllability, flame length, and fireline intensity (table 1).

There are several subjective methods for estimating fire behavior. The methods are either based on experienced judgment or require experienced judgment in their application, or both. Two such methods are associated with previously described fuel appraisal photoguides.

Maxwell and Ward (1980a, 1980b) include an assessment of fire behavior and suppression difficulty for each photo included in their guide. These assessments are based on fire model predictions for the measured fuel situation shown in the photos.

The photoguides developed by Fischer (1981a-d) provide estimates of rate of spread, intensity, torching, crowning, resistance to control, and overall fire behavior potential. Estimates are made for average bad-day conditions, which are identified in the guides. Fire managers and researchers with experience in prescribed fire and fire control assigned adjective ratings for each fire behavior element according to a uniform set of definitions. Both NFDRS and stylized fuel models are assigned to each photo in these guides.

Fahnestock (1970) developed two keys for appraising fire behavior based on fuel characteristics. One key rates relative potential rates of spread; the other rates crowning potential. Both keys require experienced judgment in use and in interpretation of results.

Another approach to evaluating fire behavior potential is simply to apply knowledge of past fire behavior in specific fuel and vegetative types under known burning conditions. This was the approach used to evaluate potential fire behavior for Fischer's (1981a-d) photo series.

**Table 1.**—Burning index interpreted in terms of fire behavior, controllability, and fireline intensity (source: Deeming and others 1977)

Burning index	Fireline intensity		Flame length		Narrative
	<i>Btu/s/ft</i>	<i>kw/m</i>	<i>Ft</i>	<i>m</i>	
0-28	0-50	0-173	2.8	0.85	Most prescribed burns are conducted in this range.
38	100	346	3.8	1.16	Generally represents the limit of control for manual attack methods.
78	500	1 730	7.8	2.38	The prospects for control by any means are poor above this intensity.
96	700	2 421	9.6	2.93	The heat load on people within 30 feet of the fire is dangerous.
108	1,000	3 459	10.8	3.29	Above this intensity, spotting, fire whirls, and crowning should be expected.

An overall evaluation of fire potential requires joint consideration of probable fire occurrence and probable fire behavior, given an occurrence.

There is no established method for expressing overall fire potential in a manner that adequately reflects the interrelationships involved. Statistical methods for dealing with probabilities do exist and have been applied to fire management problems (Hirsch and others 1979). Such methods have yet to be worked out for evaluation of fire potential as used herein.

Fire potential can be expressed and mapped as an adjectival rating, or rather two adjectival ratings; one for fire occurrence probability and one for probable fire behavior for some benchmark set of weather conditions. Any of the schemes described for estimating probable fire behavior can be used to derive adjectival ratings of low, moderate, high, and extreme fire behavior. A similar rating can be derived for probable fire occurrence by arbitrarily defining adjectival levels of low and high occurrence. Such an approach would provide eight classes of fire potential ranging from a "low occurrence-low fire behavior" class to a "high occurrence-extreme fire behavior" class.

Techniques for characterizing an area's fire occurrence, fire environment, and probable fire behavior are referenced in appendix B.

An adequate evaluation of fire potential allows the planner to answer the following kinds of questions about the planning area:

1. How many fires are likely to occur in a season and when?
2. What kind of fuels exist and where?
3. What kind of weather conditions are likely to occur at different times during the burning season?
4. How might various fuels burn under the range of likely weather conditions?

Information sources, data collection techniques, and analytical methods that can help answer such questions are included in appendix B.

## **FIRE EFFECTS**

Wilderness fire management planners need to identify fire effects that pertain to planning area ecosystems. To be useful, fire effects must be related to ecosystem classification and fire severity. Emphasis should be on characterizing the general effects of fires of varying severity on plant and animal succession and watershed properties. Fire effects information sources are included in appendix B.

### **Summarizing Fire Effects**

Fire effects information should be summarized in a way that reflects the ecosystem classification used for the planning area and the information needs of the planning effort. Effect of fire on vegetation, for example, can be summarized according to habitat type or cover type to show the effects of fire on plant succession. Habitat type fire groups (Davis and others 1980; Fischer and Clayton 1983; Crane 1983) provide a convenient way to group sites according to a similar response of tree species to fire and a similar postfire succession. Successional diagrams can be constructed for each fire group to

show basic trends in structural changes and tree species succession (Kessell and Fischer 1981). The diagrams also show general responses to fires of different intensities and different stages of recovery from the last fire.

The effect of fire on soils and water is mostly a function of fire severity, slope, soil characteristics, geology, and vegetative cover. Soil and watershed specialists have developed rating systems to predict watershed response to fire and other disturbances based on such criteria as surface erosion hazard, mass wasting potential, stream channel stability, land and stream recovery potential. Examples of such rating systems are provided by Boyer and Dell (1980) for the Pacific Northwest and by Rosgen (n.d.) for the Northern Rockies. Fire management planners should enlist the aid of local soils and watershed specialists to identify and apply local rating systems when applicable. Results of soil and watershed rating systems should be compared to relevant fire effects research to assure validity. Table 2 includes ratings for vegetative and hydrologic recovery rate and erosion hazard for the Scapegoat and Bob Marshall Wildernesses, Mont. Settergren (1969) has summarized much of the existing research on effects of fire on wildland hydrology.

Fire's effect on wildlife is most often manifested through the fire-induced change in vegetation, i.e., habitat. Models designed to predict postfire plant succession can, therefore, be interpreted in terms of wildlife habitat to yield postfire wildlife succession models. Wilderness fire management planners should enlist the aid of wildlife specialists to assist in this task.

Smoke dispersion depends on windspeed and direction and atmospheric instability. Furman's (1979) PRESCRIB and MERG 3 computer programs were designed to provide estimates of the probable occurrence and persistence of poor smoke dispersal conditions. Smoke production depends on fuel loading and the moisture content of the fuels. Wet fuels produce more smoke than dry fuels. Consequently, preseason and postseason fires will usually result in more smoke than those that occur during the fire season.

Mutch and Briggs (1976) discuss smoke as a factor in the maintenance of natural ecosystems.

## **SUMMARY OF INTERACTIONS**

Summarizing fire and ecosystem interactions requires setting down the major elements of the fire situation identified for each ecosystem. Such a summary will aid in identifying important differences in fire history, fire potential, and fire effects (tables 2 and 3). These differences can, in turn, be valuable aids for developing fire management objectives, delineating fire management units and zones, and prescribing appropriate fire management actions.

Holdorf and others (1980) use a series of aerial oblique photos to illustrate planning area ecosystems (land type associations) in the Scapegoat and Bob Marshall Wildernesses, Mont.

Five of the 14 land type associations identified by Holdorf and others (1980) are delineated on the photo in figure 4.

**Table 2.**—Characterization of the effects of fire on watershed in the Bob Marshall and Scapegoat Wildernesses: Flathead, Lolo, Lewis and Clark, and Helena National Forests, Mont. (source: Holdorf and others 1980)

LTA <sup>1</sup>	Landform	Slope class	Elevation	Dominant aspect	Dominant habitat types	Vegetative fire group <sup>2</sup>	Vegetative-hydrologic recovery rate <sup>3</sup>	Fire-induced erosion hazards <sup>4</sup>
			<i>Feet</i>					
I	Forested flood plains	0-10	4,500-5,500	None	ABLA/LIBO,	9	Rapid	Low
Ia	Wet, grass-sedge meadows	0-10	4,500-5,200	None	Willow-Sedge-Rush	0	Rapid	Low
Ib	Grass and forested stream terraces	0-10	4,800-5,200	None	ABLA/VACA, FESC/FEID	7 & 0	Rapid	Low
II	Glacial cirque basins	0-40	6,000-7,500	N & E	ABLA-PIAL/VASC, ABLA/LUHI	10	Slow	Severe (b)
III	Forested ground moraine	0-25	4,600-5,600	None	PICEA/VACA, ABLA/VACA	7	Rapid	Low
IIIa	Forested steep lateral moraine	5-60	5,500-6,800	None	ABLA/MEFE, ABLA/XETE	9	Moderate	Moderate (a)
IV	Slump land	0-40	5,000-7,500	None	ABLA/XETE, ABLA/MEFE	9	Moderate	Moderate (a)
Va	Forested high elevation ridges	0-40	6,800-8,000	None	ABLA-PIAL/VASC, ABLA/LUHI	10	Slow	Severe (b)
Vb	Forested smooth residual slopes	25-60	5,000-6,800	N & E	ABLA/XETE, ABLA/MEFE	7 & 9	Moderate	Low
Vc	Forested moderately dissected residual slopes	25-60	5,000-6,800	N & E	ABLA/XETE, ABLA/MEFE	7 & 9	Moderate	Low
Vd	Forested and grassland moderately dissected residual slopes	25-60	5,000-6,800	S & W	PSME/FEID, FESC/FEID	5	Slow	Low
Ve	Forested and grassland smooth residual slopes	25-60	5,000-6,800	S & W	PSME/FEID, FESC/FEID	5	Slow	Low
VI	Peaks and alpine ridges—sparsely vegetated rock land	60 +	6,000-10,000	All	ABLA-PIAL/VASC + SCREE	10 & 0	Slow	Low
VII	Forested, cool aspect break lands	60 +	5,500-7,500	N	ABLA/MEFE	9	Moderate	Moderate (a)
VIII	Forested, warm aspect break lands	60 +	5,500-7,500	S & W	PSME/FEID, CARU PSME/SYAL + AF/XETE + SCREE	0	Slow	Low

<sup>1</sup>LTA = land type association.

<sup>2</sup>Davis and others 1980.

<sup>3</sup>**Vegetative-hydrologic recovery:** The rating is based on estimated rates of secondary succession for habitat types occurring within the land type association. Recovery is assumed to be a 10 percent or less increase in water yield compared to mature forest cover. The rating considers factors such as evapotranspiration rates, interception losses, and redistribution of snow in forest openings. Rating definitions: rapid—less than 40 years; moderate—40 to 60 years; slow—60 or more years. Refer to Rosgen (n.d., p. 10).

<sup>4</sup>**Fire-caused accelerated erosion hazard:** This is a rating of the probability of fire-induced accelerated erosion. Rating considers water, dry creep, and mass movement erosion. The ratings are defined as follows: low—either there is no hazard or the probability is so low that it need not be considered in planning. Generally any accelerated erosion which occurs following fire will not have a measurable effect on water quality. Moderate—accelerated erosion may increase sediment load of streams but not sufficiently to affect downstream fisheries or recreation uses. Some degradation of the esthetic quality of streams occurs and if reservoirs occur downstream, accelerated sediment deposition is an added cost. High—accelerated erosion following fire produces dramatic increases in sediment loads of streams with high probability of adverse effects on fisheries and recreation uses. Sedimentation of reservoirs is an added cost.

The rating assumes a fire intense enough to kill overstory vegetation and consume litter and duff layers on most of the burned area. Fires of less intensity can and do occur but will not appreciably affect erosion rates.

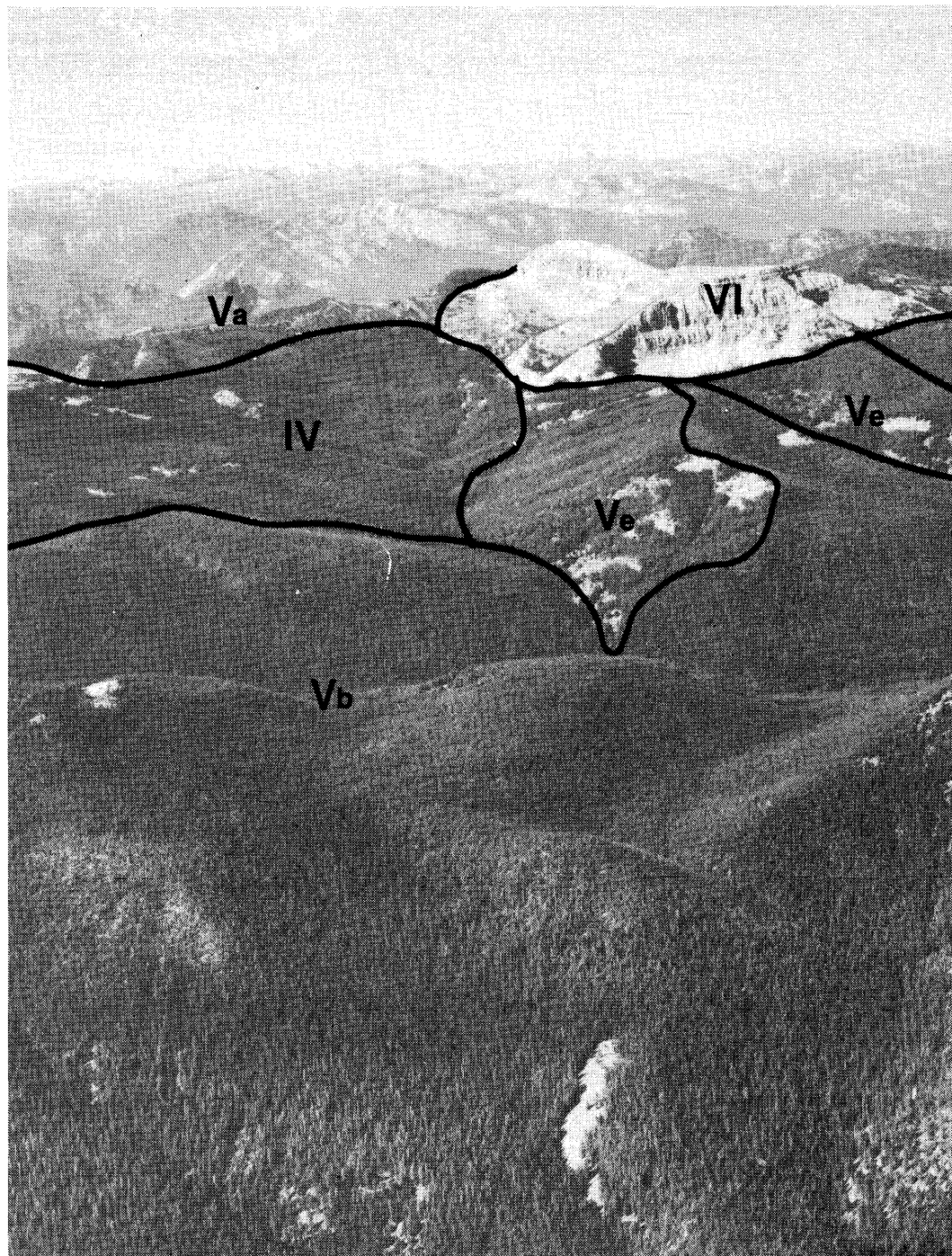
Erosive processes considered in making ratings were: (a) slumps and debris avalanches; (b) streambank erosion caused by increased water yield.

**Table 3.**—Examples of summarizing fire and ecosystems interactions for a portion of the Selway-Bitterroot Wilderness (SBW)  
(source: Fiman and Thomas 1979)

ELU <sup>1</sup> name and number	Acres	Lightning load	Micro-climate	Aspect	Fire potential	Fire cycle  <i>Years</i>	Fire season	ELU name used other SBW fire plans
ELU No. 1, strongly glaciated uplands	56,450	3.1/yr	Cold-moist	N & E	Low	100–250	Middle July– Middle September	Subalpine
ELU No. 2, frost-churned uplands	101,841	4.0/yr	Cold-moist to cold-dry	S & W all	Medium  Medium	100–200	July–September	Rolling landforms Moose Ck Lodgepole ELU West Fork RS
ELU No. 3, north-facing trough walls	24,799	1	Cold-dry	N	High	150–200	July–September	(Moose Creek, West Fork) North slope communities
ELU No. 5, south-facing scoured walls	34,114	1	Cold-dry	S	High	15–75	July–September	Ponderosa pine/ Douglas-fir South slope
ELU No. 6, wet uplands	5,740	1	Cold-wet	all	Low	100–200	July–September	—
ELU No. 7, riparian	16,076	1	Cold-wet	all	High-low	300–400	July–September	Stream bottom grand fir/cedar Stream bottom
ELU No. 8, stream break- lands, south exposure	15,929	1	Warm-dry	S	High	15–75	May–September	Ponderosa pine/ Douglas-fir South slope
ELU No. 9, stream break- lands north exposure	5,951	1	Cool-moist	N & E	Medium	150–250	July–September	North slope communities
ELU No. 10, wet draws and swales	1,414	0	Cool-moist	all	Low	150–250	July–September	—
ELU No. 11, colluvial slopes	2,560	0	Cool-moist	N & E	Low	150–250	July–September	North slope communities

<sup>1</sup>Ecological land unit (ELU) designation is roughly equivalent to land type association (LTA) as used herein.

## Sugarloaf Mtn.



**LTA IV : Slump Land**

**LTA Va: Forested High Elevation Ridges**

**LTA Vb: Forested Smooth Residual Slopes**

**LTA Ve: Forested & Grassland Smooth Residual Slopes**

**LTA VI : Peaks & Alpine Ridges - Sparsely Vegetated Rockland**

Figure 4.—Five of the land type associations identified in the Scapegoat and Danaher portion of the Bob Marshall Wilderness, Flathead, Lolo, Lewis and Clark, and Helena National Forests, Mont. (source: Holdorf and others 1980).

Kessell (1976a) used a gradient modeling approach to summarize fire and ecosystem interactions. He developed the Glacier National Park Basic Resource and Fire Ecology Systems Model, which links four major fire management components: (1) a terrestrial site inventory coded from aerial photographs that offers 33 ft (10 m) resolution; (2) gradient models of vegetation and fuel that derive quantitative stand compositional data from the parameters stored in the coded inventory; (3) a fuel moisture and microclimate model that extrapolates base station weather data to remote sites using the parameters stored in the inventory; and (4) fire behavior and fire ecology models that integrate the data from the inventory and models to calculate real-time fire behavior and ecological succession following a fire (Kessell 1976b). To adequately summarize fire and ecosystem interactions, the planner should answer the following questions for each ecosystem identified based on its fire situation:

1. What is the natural role of fire?
2. How has fire suppression affected physical and biological characteristics?
3. When, where, and what kind of fires are likely to occur?
4. Are fires likely to intrude from an adjoining area?
5. How will future fires of varying intensity affect physical and biological characteristics?
6. How will fire exclusion affect physical and biological characteristics?
7. What environmental impacts are associated with various fire suppression methods and fire management strategies?

## Special Resource and Use Considerations

Most wildernesses have unique features and permitted uses that require special consideration when planning fire management. Such areas should be identified, described, and mapped. This is often done in a higher level plan. Areas requiring special consideration include:

1. Ecological, archeological, geological, and other features of scientific, scenic, or historical value.
2. Rare, endangered, and threatened plant sites and animal habitats.
3. Administrative sites and improvements.
4. Designated recreation sites.
5. Grazing allotments.
6. Oil, gas, and mineral exploration sites.
7. Non-Federal land within and immediately adjacent to boundaries.

Appropriate specialists (archeologists, geologists, ecologists, wildlife biologists, etc.) should assist in identifying special areas and in appraising probable effects of fire, fire exclusion, and fire suppression.

The important question to be answered is: How might fire or the absence of fire affect ecologic, archeologic, geologic, and other features of scientific, scenic, historical, or cultural value?

## Fire Management Objectives

Wilderness fire management objectives state the planned measurable results desired from a wilderness

fire management program. The overall goal toward which wilderness fire management objectives should be aimed is the preservation and enhancement of the wilderness resource through a well-planned and well-executed fire protection and use program that is ecologically sound and cost effective.

Fire management objectives for a specific wilderness planning area depend on the fire-ecosystem interactions, special resource and use considerations identified for the area, and the wilderness management objectives set forth in the wilderness management plan or other appropriate land management plan. As indicated earlier, relevant fire management policy and other direction should be reflected in the wilderness management objectives. If for some reason they are not, they should also be identified and used as a basis for defining specific wilderness fire management objectives.

Defining specific fire management objectives is the critical element in wilderness fire management planning. When this has been done, the remaining planning effort is devoted to developing criteria and devising methods that assure accomplishment of the fire management objectives.

Fire management objectives should be clearly stated and explicit. They should encourage fire use where such use is ecologically sound and beneficial to management objectives. Conversely, fire protection should be required where necessary to assure visitor safety, protect private property, and to avoid undesirable environmental impacts and detrimental effects in terms of the wilderness resource. The following is a list of management goals and associated objectives relevant to many wilderness-type areas:

Goals	Objectives
Allow fire to achieve its natural <sup>3</sup> role.	<ol style="list-style-type: none"> <li>1. Perpetuate naturally occurring plants and animals.</li> <li>2. Perpetuate natural vegetative patterns.</li> <li>3. Maintain "natural" fire regime.</li> </ol>
Use fire to accomplish desired resource management objectives	<ol style="list-style-type: none"> <li>1. Restore fire where exclusion has had adverse effects.</li> <li>2. Create, maintain, or enhance habitat for threatened, endangered, or desired plants and animals.</li> </ol>
Protect life, property, and resources from unwanted fire.	<ol style="list-style-type: none"> <li>1. Protect visitors.</li> <li>2. Protect scientific, scenic, or historical values.</li> <li>3. Protect recreation, administrative, and other imposed sites.</li> <li>4. Protect intermingled and adjacent nonwilderness lands.</li> </ol>
Avoid unacceptable effect of fire and fire suppression.	<ol style="list-style-type: none"> <li>1. Maintain acceptable air quality.</li> <li>2. Use low impact fire suppression techniques.</li> <li>3. Prevent unauthorized man-caused ignitions.</li> <li>4. Avoid prescribing fire of "unnatural" severity.</li> </ol>

<sup>3</sup>Natural means being in accordance with and determined by nature; untouched by the influences of civilization and society.



This list does not exhaust the range of possible wilderness fire management objectives, and some of the listed objectives may be inappropriate for a given wilderness area. But identification of objectives is the first step in fire management. Fire management objectives should flow from the land management plan for the wilderness and should, consequently, be largely developed by wilderness managers and resource specialists. Fire management objectives should include such specifics as what, where, when, and so on. If, for example, an objective is to maintain favorable habitat for a rare species, the objectives should identify the species, describe favorable habitat conditions, and tell how much habitat needs to be maintained.

## Fire Management Units and Zones

Fire management area (FMA) is, as indicated earlier, the term used to denote a planning unit. Fire management unit (FMU) and fire management zone (FMZ) are terms used to denote parts of a fire management area. Fire management unit and fire management zone are often used as synonyms. They are not so used here. **A fire management unit is a distinct part of the fire management area that can be recognized and mapped from its external features.** A particular drainage within a fire management area is an example of a fire management unit. It is, in a sense, a mini-fire management area. **A fire management zone refers to all the land within a fire management area that has in common a particular characteristic.** The shared characteristic can be physical, biological, or use-related; for example, all the land above 9,000 ft (2 743 m) or all land that comprises critical grizzly bear habitat or grazing allotments.

Fire management units and zones are delineated to help the planner write fire management prescriptions and develop and implement fire management actions. They enable the planner to focus on a particular piece or type of land and make integrating fire-ecosystem interactions, special resource and use considerations, and fire management objectives manageable.

The nature of the fire management area and the associated fire management objectives should determine whether fire management units, fire management zones, or both units and zones are delineated. Fire management zones are often used to divide a small fire management area that has relatively uniform characteristics. Fire management zones are also appropriate when fire management objectives are few and result in relatively simple fire prescriptions. Fire management units are often appropriate for dividing large fire management areas of diverse characteristics and for areas of any size where fire management objectives vary and require complex prescriptions. Both fire management units and fire management zones may be required in certain situations. A likely case would be a large fire management area requiring division into many large fire management units, each of which has several fire management objectives and special resource and use considerations.

Stratification of a wilderness fire management area into fire management units (FMU) and fire management zones (FMZ) depends on area size; physiognomy;

ecosystem diversity; the fire situation; presence of unique features, special uses, and improvements; land ownership patterns; and fire management objectives.

## FIRE MANAGEMENT UNITS

Fire management units should be rather large homogeneous areas with boundaries that are natural barriers to fire spread or that at least provide a reasonable chance for fire containment. Mountain wildernesses can usually be divided into fire management units that correspond to major drainage patterns. Planning areas that lack a pronounced topography can be divided into units based on past fire patterns, major changes in vegetation or fuel type, or other appropriate criteria. Based as they are on external features, fire management units can easily be located on aerial photos.

Wilderness fire management planning and implementation can be based on a fire management unit basis if management units are delineated early in the planning process. Planning can then proceed one unit at a time.

## FIRE MANAGEMENT ZONES

A fire management zone consists of one or more parcels of land within the planning area; these parcels have common fire management objective(s) that can be satisfied by a common fire management prescription. Fire management zones are usually composed of similar ecosystems having similar fire situations. They may, however, also reflect common special features or use considerations.

Delineating fire management zones is a synthesizing process. The fire management planner must translate wilderness fire management objectives into planned management responses to fire on specific pieces of land within the planning area.

A first step in identifying fire management zones is to aggregate lands on an ecological basis. The next step is to scrutinize the fire situation in ecologically similar units. Probable fire behavior and associated fire effects are key considerations during this step. The evaluation may produce new groups based on even more specific classification. During the next stage, the manager must determine which lands require a fire management strategy that depends on considerations other than physical and biological characteristics and the fire situation. Included in this category are areas of ecological, archeological, geological, and other features of scientific, scenic, or historical value. Other considerations are grazing allotment, mineral lease, wildlife habitat, and private property. Special fire management zones can be created to reflect the special fire management needs of such lands.

The final outcome of this process will be a number of fire management zones, each requiring a unique fire management strategy to accomplish stated fire management objectives for the planning area. Each of these zones should be described and their boundaries mapped. Managers should clearly state fire management objectives and the desired response to fire for each zone.

The number of fire management zones described for a planning area depends on the number of different responses to fire desired and whether or not these

responses are absolute or conditional. In other words, is the desired response required at all times under all burning conditions or does it vary by time of year, weather conditions, or other variables?

Fire management zones usually reflect four primary responses to fire: (1) fire suppression, (2) observation, (3) scheduled prescribed fire, and (4) conditional fire management. Almost every existing wilderness fire management plan, for example, has areas where any fire at any time is undesirable. Such areas can be described as being in **automatic fire suppression zones** or **fire exclusion zones**. Other areas where fire is considered undesirable, but where damage potential varies with site or burning conditions, might be designated as falling into **delayed attack zones**. Fires occurring in such areas may not always need immediate attack. Still other areas where fire is generally unwanted may be designated as **modified attack zones** in order to prohibit fire suppression techniques deemed unacceptable because of adverse environmental impact. A primary response to fire, total suppression in this example, results in the designation of three fire management zones. Another primary fire response is to allow all fires to burn as unscheduled prescribed fires regardless of time of year, burning conditions, or other variables. Areas for which such a strategy is appropriate can be designated as **observation zones**. Areas designated for treatment with scheduled prescribed fires might be included in a single **scheduled prescribed fire zone**.

In many wilderness fire management planning areas, most lands will fall into one or more **conditional fire management zones** designed to allow a conditional

response to fire, depending on time of year, elevation, burning conditions, and other variables. Such zones are labeled in a variety of ways, depending on external features, vegetation, use considerations, and other factors that best indicate the basis for creating the fire management zone.

The designation of fire management zones and the assignment of lands to fire management zones is interrelated with the development of fire management prescriptions for the zones. This is another case where planning steps are not clear cut. One distinction that can be made between these two tasks is that fire management zones are delineated by the kind of fire desired or expected; fire prescriptions are based on conditions likely to result from the desired or expected fire.

There is an important relationship between fire management zones and fire management units. A properly designated fire management unit imposes an area constraint to fires that may burn within the unit's boundaries.

Each fire management unit and zone should be delineated on a map of the fire management area. A brief written description of each unit and zone should include information about important fire-ecosystem interactions, special resource and use considerations, and relevant fire management objectives.

### Teton Wilderness Example

The relationship between fire management unit and fire management zone is reflected in figure 5. This example is from the Teton Wilderness fire management plan

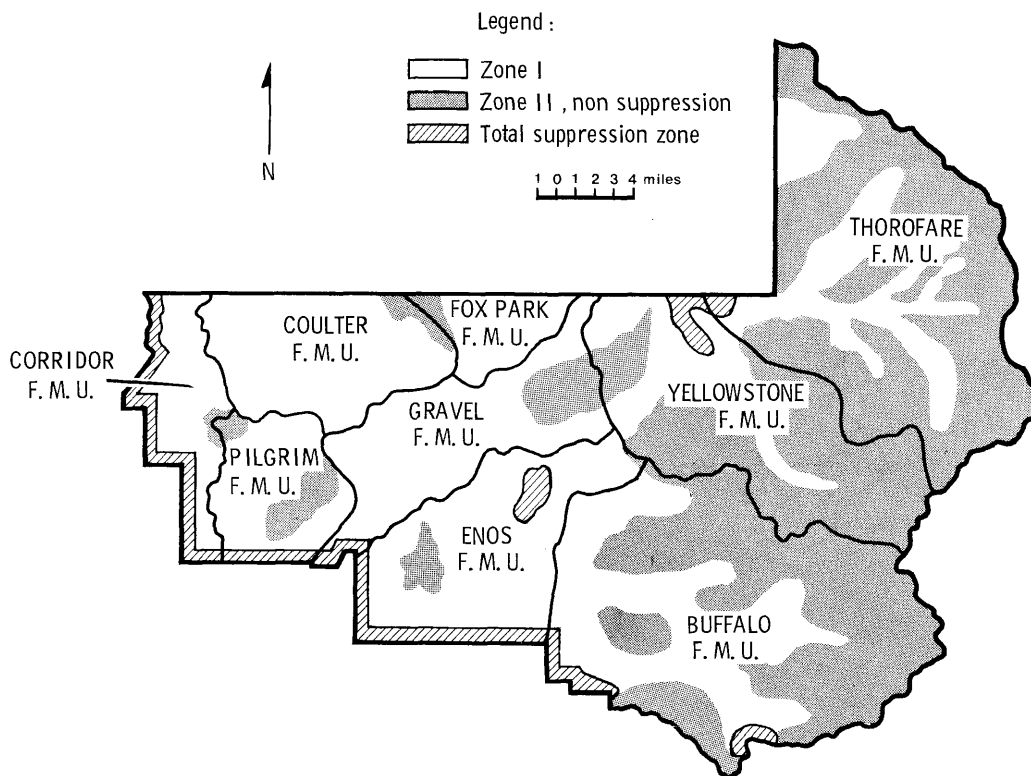


Figure 5.—Fire management units and zones, Teton Wilderness, Bridger-Teton National Forest, Wyo. (source: Reese and others 1975).

(Reese and others 1975). The fire management units are areas with recognizable and defensible boundaries, mostly drainage divides. The fire management zones reflect fire management objectives.

### Cabinet Wilderness Example

A slightly different approach is shown by figure 6. This example is from the Cabinet Wilderness fire management plan (Schulte and Davis 1980). Two broad fire management zones have been established in the Cabinet Wilderness. These are described below:

1. The high elevation fire management zone<sup>4</sup> covers most of the wilderness. It is characterized by scree habitat types, shrub fields, and stands of scattered trees or clumps of trees in the subalpine zone. While the northwest portion of this area has some dense timber stands, there are no extensive tracts of continuous trees or fuels. Natural landforms, such as slides and rock outcroppings, will act as barriers to fire spread.
2. The remainder of the wilderness has been divided into four fire management units (see footnote 4). They are the Cedar Creek, Granite Creek, East Fork, and

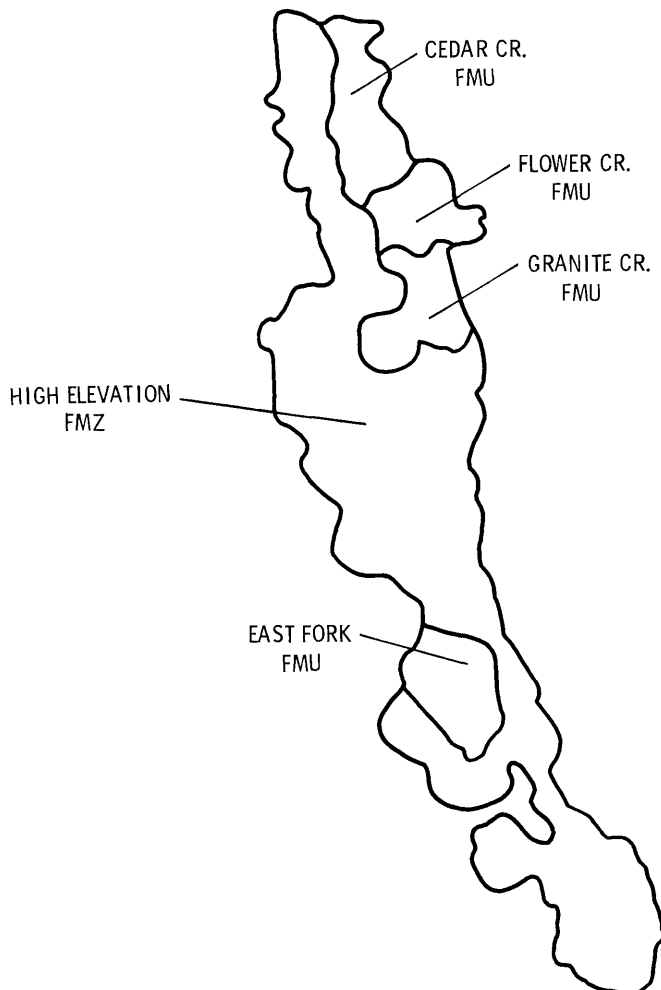


Figure 6.—Fire management units and zones, Cabinet Wilderness, Kootenai National Forest, Mont. (source: Schulte and Davis 1980).

Flower Creek fire management units. These units deserve special considerations because of heavy, continuous fuels and dense forest cover.

Also, these units receive considerable use by visitors due to ready access by trails. In addition, the Flower Creek drainage is the municipal watershed for the town of Libby, Mont.

### Everglades National Park Example

The terrestrial mainland portion of Everglades National Park is divided into three fire management units, with three subunits (fig. 7). Delineation is based primarily on vegetation and fire ecology.

### Fire Management Prescriptions

A fire management prescription is a written direction for dealing with the threat, occurrence, and use of fire within a fire management area, unit, or zone to accomplish land management objectives. Note that the scope of a fire management prescription is broader than that of a fire prescription. A fire prescription is a written direction for the use of fire. Traditional fire prescriptions are usually limited in scope. They primarily deal with the conditions under which a fire will be ignited, ignition techniques, and other factors directly related to the conduct of a burn. A fire management prescription must include necessary direction for the detection, prevention, and suppression of fires as well as for the use of fire.

Fire management prescriptions are usually written for a fire management unit or zone. Sometimes a single prescription will apply to several units with similar characteristics and fire management objectives. A single fire management prescription could conceivably apply to an entire wilderness fire management area, but such a situation is rare. The fire management prescription represents the culmination of fire management planning. Fire and ecosystem interactions, special resource and use considerations, and fire management objectives become manifest in the fire management prescription for a fire management unit or zone. The fire management plan, the final planning element, is a direct result of the fire management prescription(s). The plan tells how fire management prescriptions will be implemented.

The fire management prescription establishes standards upon which fire management decisions may be based. Criteria should be established for all fire management activities necessary to accomplish fire management objectives for the area of land covered by the prescription.

<sup>4</sup>Terminology has been changed to conform with usage in this guide. Both the zones and units described above are called "areas" in the Cabinet Wilderness fire management plan.

## EVERGLADES NATIONAL PARK FIRE MANAGEMENT UNITS

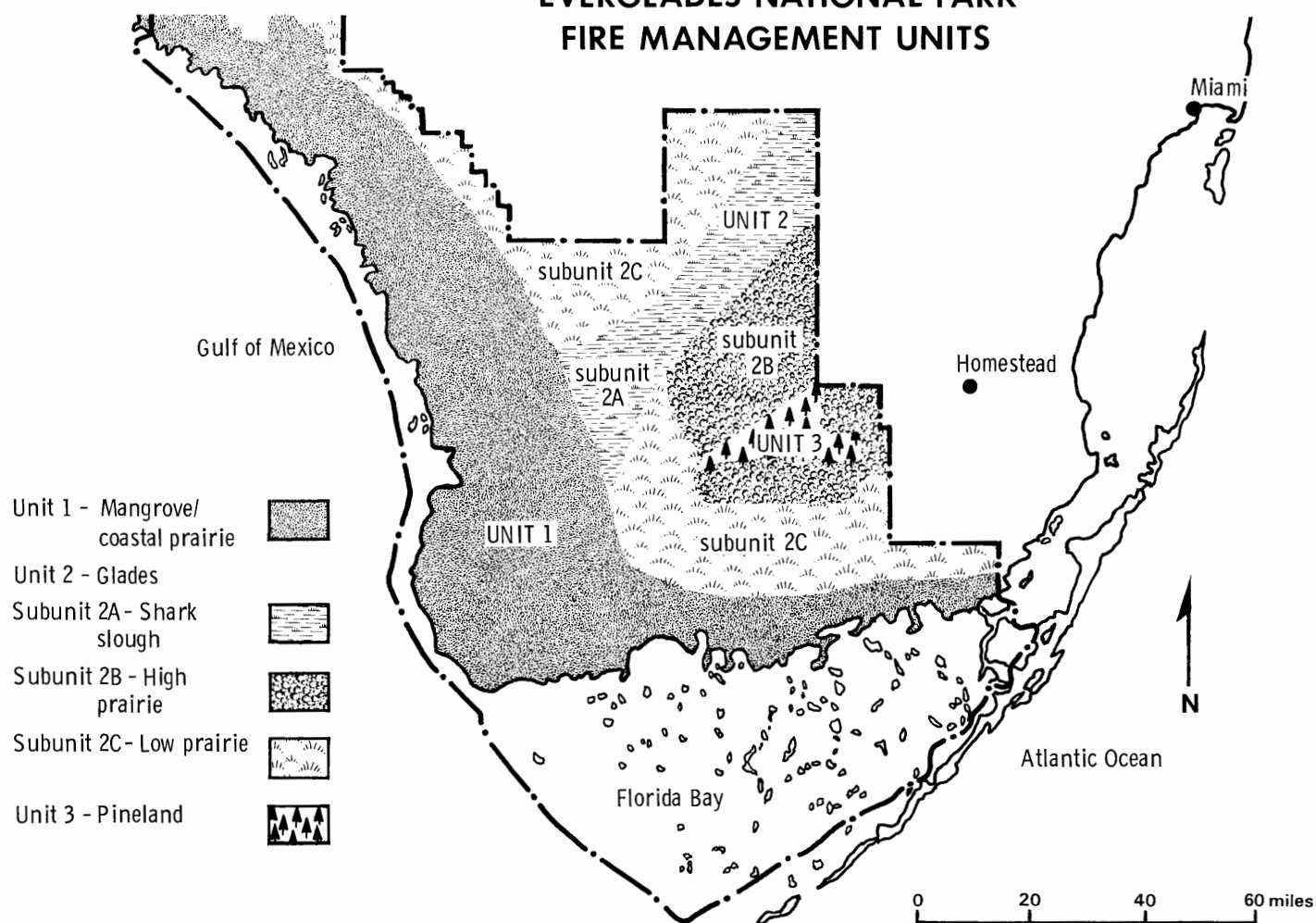


Figure 7.—Everglades National Park, Fla., fire management units (source: Koepp and Taylor 1979).

### PRESCRIPTION DEVELOPMENT

It is difficult to suggest a step-by-step method for developing fire management prescriptions. Prescriptions that satisfy a given management objective in one planning area may fail to satisfy the same objective in another. No methodology can substitute for an intimate knowledge of the planning area, clear and concise management objectives, and a journeyman's knowledge of fire suppression, fire behavior, and fire effects. The following approach requires all four of these capabilities.

Partitioning the planning area into fire management zones and units can be an important first step in prescription development because such zoning reduces the often varied landscape to a manageable number of ecological land units and special areas for which prescriptions must be written. Preliminary prescriptions can be developed for each zone based on the fire response desired in each zone. After preliminary prescriptions have been developed, each zone can be evaluated on a fire management unit basis. The lands within a given management unit may fall into a number of fire management zones; within each unit, prescriptions

for neighboring zones must be compatible. To illustrate this point, consider a special fire management zone with a prescription that requires total fire suppression and an adjoining downslope zone where the prescription calls for allowing certain fires to burn as unscheduled prescribed fires. Unless there is a natural barrier to fire along their common boundary, these prescriptions could be incompatible. Fire suppression might often be required to keep fire from entering the total suppression zone. This is not cost-effective fire management. As a general rule, prescriptions for adjoining zones should consider the natural fire spread tendency of a free-burning fire given the topography of the management unit. To deal with such situations, fire management zone designations must often be adjusted or preliminary zone prescriptions altered to reflect actual on-the-ground situations within a given fire management unit. It is unrealistic to expect all prescribed fires to remain in prescription unless the prescription is broad enough to allow a fire to encompass all the flammable area in its natural path. It is also unrealistic to depend on control action as a regular means of containing fires within a designated area.

Minimal control or holding action along a well-defined natural barrier to fire spread is the only practical approach to using unscheduled prescribed fire for attaining wilderness management objectives.

Another reason to prescribe fire management on a unit-by-unit basis is that fire management activities such as detection, prevention, and presuppression are best prescribed for a homogeneous unit of land that is easily identifiable on the ground.

Suggested procedures for developing prescriptions for scheduled prescribed fires are generally available (Mobley and others 1973; Martin and Dell 1978; Fischer 1978). Such prescriptions should contain directions for responding to unscheduled fire that might occur in areas where prescribed fires are scheduled.

## **PRESCRIPTION CRITERIA**

As indicated earlier, fire management zones are based on the planner's interpretation of acceptable and unacceptable fires with respect to management objectives. To develop fire management prescriptions, the planner must also consider the conditions under which these acceptable and unacceptable fires are likely to occur. A fire management zone may be described, for example, as a zone in which preseason and postseason surface fires of low severity will be allowed to burn. To write a prescription for this zone, criteria must be established for preseason and postseason fires, for low severity fire, and for surface fire. These criteria must be measurable and must be immediately determinable at the time a fire is discovered. Examples of commonly used prescription criteria are elevation, calendar date, and fire danger rating indexes.

Selecting prescription criteria requires knowledge of the relationship between prescription variables and fire behavior. Some useful guides for this purpose are provided by Deeming and others (1977) and Albini (1976). A useful source of information is local records of fire occurrence and fire danger.

## **CONSTRAINTS**

Fire management prescriptions are not complete until all constraints not previously considered are identified, defined, and incorporated into the prescription. Common constraints that often apply to wilderness fire management prescriptions have to do with:

**Man-caused fires.**—Agency policy often prohibits the use of accidental man-caused fires to accomplish management objectives.

**Scheduled prescribed fires.**—Agency policy may prohibit or restrict scheduled prescribed fires in wilderness.

**Level of fire activity.**—Prescribed fire programs are often shut down during periods of high fire activity.

**Crew availability.**—Use of unscheduled ignitions to accomplish management objectives is often tied to the availability of fire crews to handle possible escapes.

**Suppression methods.**—A complete ban on certain fire suppression methods and use of certain firefighting equipment is often imposed in wilderness.

**Air quality guides.**—Smoke management plans often restrict or prohibit prescribed fires during periods of poor ventilation.

**Life and property.**—Visitor safety and private property must always be protected.

Additional constraints may exist, depending on the particular situation. It is important to recognize all constraints during planning so that they can be reflected in fire management prescriptions.

## **ORGANIZATION AND CONTENT**

The organization and content of fire management prescriptions should reflect the fire management situation on the planning area. Some prescriptions can be quite simple because the fire management activities planned for the area are quite simple. Other prescriptions will be complex. The following suggested outline should handle most situations. Each item (A-C) should be repeated for each management unit.

### **SUGGESTED OUTLINE FOR FIRE MANAGEMENT PRESCRIPTION**

- I. Fire Management Unit (name or number)
  - A. **Fire detection.** If special detection needs are indicated, enumerate them and describe criteria for initiating action. If planning area detection is covered in some other fire management plan, cite the plan and summarize pertinent information.
  - B. **Fire prevention.** Indicate all special fire prevention actions planned for the unit. Describe criteria for initiating action. If planning area prevention actions are covered in some other fire management plan, cite the plan and summarize pertinent information.
  - C. **Presuppression.**
    1. **Preattack.** If the area is covered by a preattack plan, cite the plan and summarize pertinent information. If preattack plan does not exist, preattack procedures should be developed as part of the planning process and described here. Preattack procedures will depend on the fire potential and constraints imposed by fire prescriptions (Aldrich and Mutch 1973). USDA Forest Service preattack planning guides are available for many parts of the United States (for example, USDA Forest Service 1978b; Dell 1972).
    2. **Fuel management.** Planned fuel management actions should be enumerated. In many wildernesses fuel management is limited to slash disposal in conjunction with trail construction and maintenance. Fuel treatment on outside lands along wilderness boundaries may be appropriate in some cases.

3. **Fire prescriptions.** Details on the planned response to a fire occurrence should be described separately for each fire management zone.  
**For each fire management zone describe:**
  - a. Conditions when fires will be aggressively attacked and suppressed,
  - b. Conditions when fires will be suppressed, but attack will be less than aggressive,
  - c. Constraints on fire attack and suppression,
  - d. Conditions when unscheduled fires will be allowed to burn as prescribed fires,
  - e. Constraints on allowing unscheduled fires to burn as prescribed fires, and
  - f. If prescribed fires are scheduled in the fire management zone, fire prescriptions for each planned fire.

Alternative prescriptions for unscheduled prescribed fires can be evaluated with the aid of a computer system designed by Bevins and Fischer (1983a,b). The technique uses historical fire occurrence and weather records to identify ignitions that would meet manager-specified criteria for prescribed fires. Qualifying fires are "allowed to burn" under prevailing weather conditions until extinguished by precipitation or until prescribed conditions are exceeded.

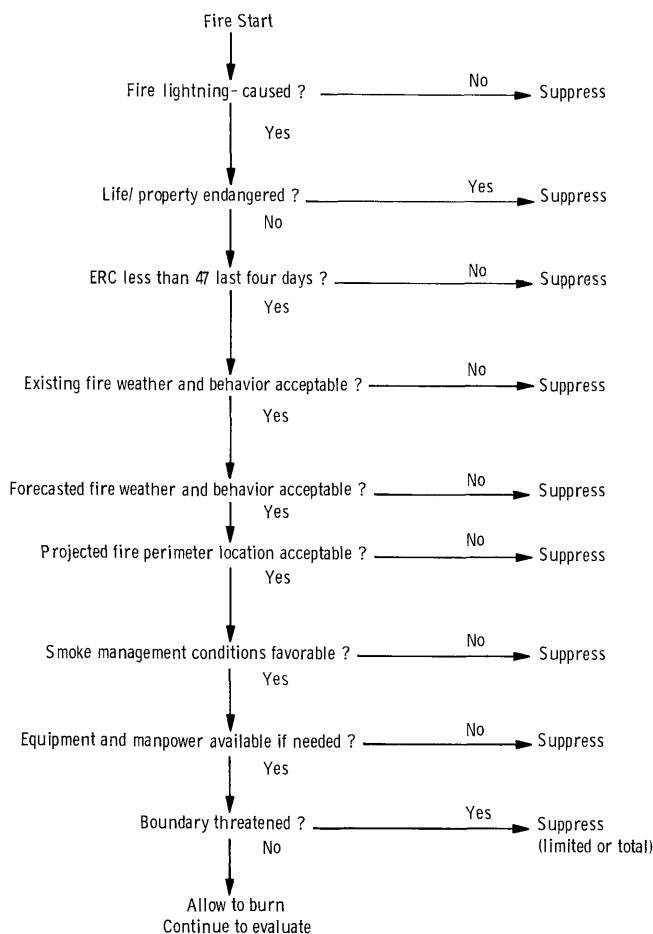


Figure 8a.—Decision flow chart for evaluating fires occurring in high elevation fire management zone against prescription criteria, Cabinet Wilderness (see fig. 6), Kootenai National Forest, Mont. (source: Schulte and Davis 1980).

## Fire Management Plan

Fire management prescriptions tell how to achieve fire management objectives for the planning area. The fire management plan tells who will do what and when and where the fire management objectives will be accomplished.

### DECISION SCHEME

A major part of the fire management plan is a decision scheme for implementing the fire management prescriptions for the planning area. The decision scheme assures that all prescription criteria and constraints are systematically considered before a response to a fire is selected. It should allow the fire manager to quickly determine if a fire is a wildfire or an unscheduled fire as defined by the fire prescription. The scheme should also indicate, again according to the prescription, what type of attack and suppression methods are appropriate if wildfire is indicated. This same decision scheme, if properly constructed, is used to help determine if a prescribed fire continues to burn within prescription on a daily basis (fig. 8).

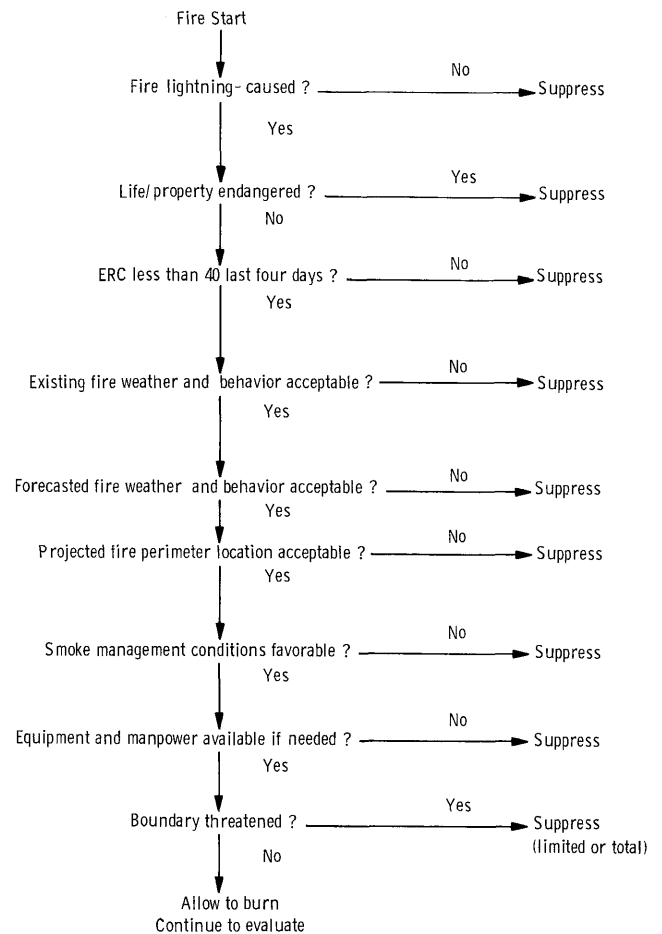


Figure 8b.—Decision flow chart for evaluating fires occurring in Cedar Creek, Granite Creek, and East Fork fire management units against prescription criteria, Cabinet Wilderness (see fig. 6), Kootenai National Forest, Mont. (source: Schulte and Davis 1980).

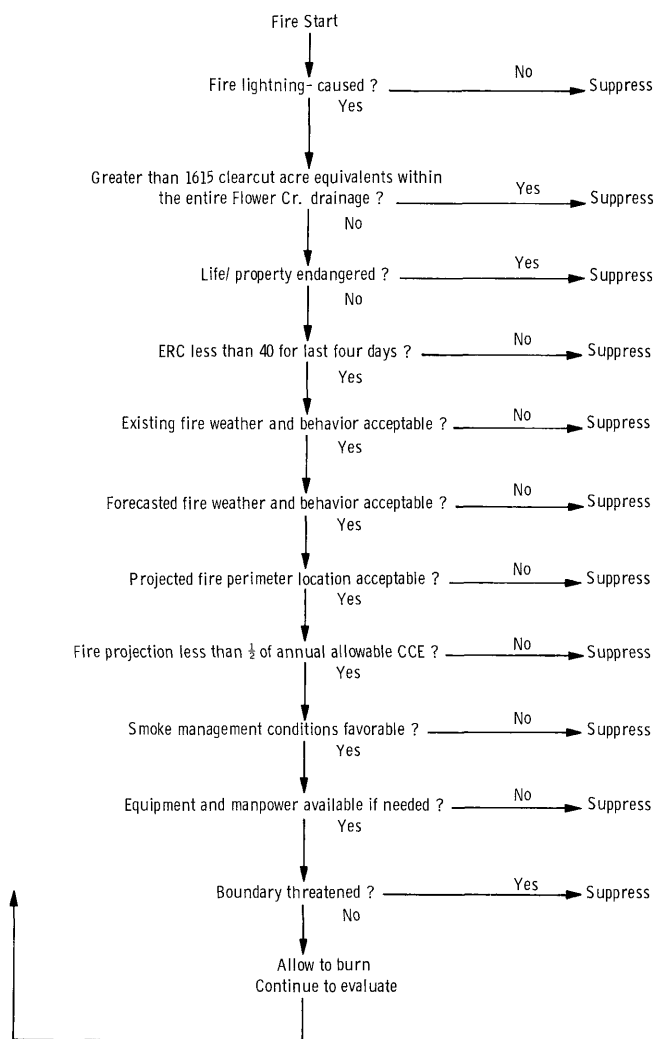


Figure 8c.—Decision flow chart for evaluating fires occurring in Flower Creek fire management unit against prescription criteria, Cabinet Wilderness (see fig. 6), Kootenai National Forest, Mont. (source: Schulte and Davis 1980).

## ASSIGNMENT OF RESPONSIBILITY

The plan should identify who is responsible for determining appropriate action regarding fire. Fire management prescriptions and associated decision schemes are guides for decisionmaking. Decisions regarding fire should rarely, if ever, be automatic. Current technology for predicting fire behavior and associated fire effects is imperfect, and the probability of unanticipated burning conditions is great. Decisions must be based on what a fire is actually doing and what it is likely to do, not on some prefire prediction of what it is supposed to do. Fire management decision systems should, consequently, always include diagnosis by experienced fire and resource specialists. The plan should require such diagnosis and specify the level of expertise required of such decisionmakers (fig. 9).

## FIRE MONITORING

Assignments and procedures for collecting and reporting the information required to evaluate fire starts in terms of prescription criteria are a part of the plan. Procedures for fire monitoring and qualifications of fire monitors should be included unless established standards apply. **Fire monitoring is the act of observing a fire to obtain information on its environment, behavior, and effects for the purpose of evaluating both the fire and its prescription.** Fire monitoring provides the information needed to make daily decisions regarding prescribed fires. Fire monitoring also supplies information needed to cope with agency requirements for documenting fire management actions. Information gathered by qualified fire monitors can be used to verify or adjust fire prescriptions. The National Wildfire Coordinating Group has published an excellent guide to assist in the operational monitoring and evaluation of prescribed fires (Van Wagtendonk and others 1982).

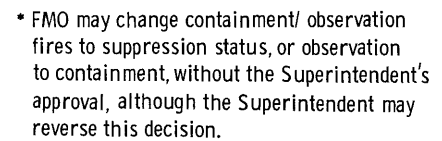
## SCHEDULED PRESCRIBED FIRES

A schedule of all manager-conducted prescribed fires planned for the wilderness is an important part of the plan. Burning plans for these fires should also be included (for example, see Mobley and others 1973; Martin and Dell 1978; Fischer 1978). A separate decision scheme for identifying prescribed conditions for scheduled fires may be desirable.

## EVALUATION OF FIRE EFFECTS

The actual effect of a prescribed fire or a wildfire in terms of wilderness fire management objectives is the ultimate test of the fire management prescription. The plan should contain a fire effects evaluation procedure and a procedure to use results of such evaluations to make necessary adjustments of prescriptions. Some examples of wilderness fire evaluations are provided by Collins (1980), Garcia and others (1979), Gochnour and Bailey (1980), Keown (1980), Racine (1979), and USDA Forest Service (1979).





## PUBLIC INFORMATION AND INVOLVEMENT

The planned use of fire to accomplish wilderness management objectives is new. Few wilderness fire management prescriptions have been tested over a range of fire conditions. The support of resource managers and the general public is necessary to develop wilderness fire management effectiveness. Wilderness fire management plans should, therefore, outline a program of public involvement and information regarding planned fire management activities in the wilderness. This program should include participation by the Agency, as well as by cooperating Federal and State agencies.

Newlon (1981) identified two major aspects to public involvement in fire management: (1) doing a good technical job of managing fires and (2) telling the public about the good job you are doing. He suggests the following basic steps be considered when planning a public involvement program:

1. Define the issues in legal, ecological, social, and economic terms.
2. Communicate in layman's English, or in other languages—Spanish, French—as appropriate.
3. Make public involvement an integral part of any plan, program, or project and not a separate procedure.
4. Provide full and timely information about upcoming fire management decisions, and offer many opportunities for the public to be involved in the decisionmaking process.
5. Identify the publics affected by the program or project and help them participate in the planning process.
6. Collect comments from the public, analyze them, and respond to recommendations.
7. Document all public participation; describe how the public's input was used in the decisionmaking processes.

The skills needed, steps to be considered, and techniques to carry out effective public participation programs are thoroughly discussed in the USDA Forest Service Public Participation Handbook, Parts I and II (USDA Forest Service 1980).

## NOTIFICATION AND REPORTING

Requirements for notifying designated agency and cooperator agency officials and filing necessary in-service reports of wilderness fire management activities should be spelled out in the plan. Responsible individuals should be identified by name and position.

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# APPENDIX A: PARK AND WILDERNESS FIRE MANAGEMENT PROGRAMS, 1972-81

**Table A-1.**—Prescribed fire programs in National Parks and Monuments (adapted from Sellers 1982) (source: Kilgore 1983)

Parks and monuments by region	Size	Natural fire zone	Years covered	Prescribed fire			
				Lightning ignitions		Human ignitions	
	-----Acres-----			No.	Acres	No.	Acres
Pacific Northwest							
Crater Lake	160,290	110,000	1976-1980	6	542	2	4,225
North Cascades	504,785	430,000	1976-1980	52	1,471	—	—
Western							
Grand Canyon <sup>1</sup>	1,226,656	1,077,000	1971-1981	33	3,527	12	2,771
Chiricahua	11,440	2,000	1979-1981	—	—	7	46
Hawaii Volcanoes	229,117	96,000	1977-1981	2	698	7	1,108
Lassen Volcanic	106,372	106,000	1979	2	4	—	—
Lava Beds	46,821	—	1974-1981	—	—	30	3,105
Pinnacles	16,215	—	1974-1981	102	1,265	—	—
Point Reyes	68,000	—	1979-1981	—	—	27	1,418
Redwoods	160,000	—	1980-1981	—	—	10	72
Saguaro	83,576	56,000	1971-1981	51	927	—	—
Sequoia-Kings Canyon	862,429	740,000	1968-1981	208	21,982	93	21,412
Whiskeytown	43,500	—	1980-1981	—	—	7	66
Yosemite	761,094	656,000	1970-1981	239	17,525	56	18,364
Santa Monica	6,000	—	1981	—	—	1	30
Southwest							
Big Bend	708,221	533,000	1980-1981	2	680	—	—
Carlsbad-Guadalupe	46,755	—	1979-1981	—	—	2	4
Bandelier	36,971	12,000	1980-1981	6	75	—	—
Rocky Mountain							
Dinosaur	211,050	206,000	1980-1981	3	—	1	60
Glacier	1,013,594	100,000	1980-1981	—	—	1	5
Grand Teton	310,418	145,000	1972-1981	23	5,553	1	35
RockyMountain <sup>2</sup>	263,793	—	1973-1978	17	1,051	—	—
Wind Cave	28,060	—	1973-1981	—	—	24	3,299
Yellowstone	2,221,772	1,700,000	1972-1981	114	33,169	—	—
Devil's Tower	1,350	—	1974-1975	—	—	3	51
Midwest							
Isle Royale	571,976	132,000	1976-1980	1	5	—	—
Homestead	163	—	1970	—	—	1	90
Fort Larned	718	—	1968-1975	—	—	56	450
Herbert Hoover	186	—	1972	—	—	1	76
Pipestone	282	—	1976-1980	—	—	66	859
Southwest							
Big Cypress	570,000	—	1978-1981	—	—	44	13,225
Everglades	1,400,533	705,000	1951-1981	160	46,758	281	112,661
Mid-Atlantic							
Shenandoah	194,078	—	1975-1981	—	—	10	159
North Atlantic							
Cape Cod	44,600	—	1977	—	—	1	40
<b>TOTAL</b>	<b>6,794,000</b>			<b>919</b>	<b>133,967</b>	<b>846</b>	<b>183,674</b>

<sup>1</sup>Natural prescribed fire program at Grand Canyon began in 1978.

<sup>2</sup>Rocky Mountain's program suspended in 1978 after Ouzel Fire had to be suppressed.



**Table A-2.**—Natural fire programs in National Forest wilderness, 1972-81 (source: Kilgore 1983)

Area	Plan approved	Acres			Fires allowed to burn	Acres within fire perimeter
		Wilderness	nonwilderness	Total		
REGION 1						
Anaconda-Pintler Wilderness	1978/79		159,086	2	125	
Beaverhead NF		72,383				
Bitterroot NF		41,344				
Deerlodge NF		45,359				
Selway-Bitterroot Wilderness				1,134,086		
Clearwater NF	1979	265,779			76	38,855
Bitterroot NF	1972/78	308,795				
Nezperce NF	1974/78	559,512				
High Elevation Bitterroot FMA	1978	68,960	8,840	77,800		
Bitterroot NF						
Camp Tolan FMA	1978		39,848	39,848		
Bitterroot NF						
Troy Ranger District FMA	1979		309,272	309,272	1	542
Cabinet Mountains Wilderness	1980	94,272		94,272		
Kootenai NF						
Scapegoat Wilderness and Danaher Unit, Bob Marshall Wilderness	1981			433,900	2	232
Flathead NF		166,200				
Helena NF		80,700	6,300			
Lewis and Clark NF		80,600	19,200			
Lolo NF		74,800	6,100			
Upper Rock Creek FMA	1982		175,699	175,699		
Deerlodge NF						
Absaroka-Beartooth Wilderness	1982	921,574		921,574		
Gallatin NF and Custer NF						
REGION 1 TOTALS				3,343,325	81	39,754
REGION 2						
Dolores FMA	1978		498,000	498,000	38	31
Mancos FMA	1978		187,000	187,000	6	2
San Juan NF						
Washakie Wilderness	1978	687,132		687,132	3	26
Shoshone NF						
North Absaroka Wilderness	1979	351,104		351,104	0	0
Shoshone NF						
Flat Tops Wilderness	1979	235,230		235,230	0	0
White River NF						
REGION 2 TOTALS				1,958,466	47	59
(con.)						

(con.)

Table A-2.—(con.)

Area	Plan approved	Acres			Fires allowed to burn	Acres within fire perimeter
		Wilderness	nonwilderness	Total		
REGION 3						
Gila Wilderness Gila NF	1975	162,990	8,830	171,820	95	10,903
Blue Range Primitive Area Apache-Sitgreaves NF	1979	169,000	24,000	193,000	24	7,100
A/S other			22,400	22,400		
Galiuro FMA	1978	52,717	85,529	138,246	1	50
PuschFMA	1982	56,430		56,430		
Rincon FMA	1978		73,600	73,600		
Coronado NF						
San Pedro FMA Santa Fe NF	1978	41,132		41,132	4	—
Natural fire areas Coconino NF	1979		319,100	319,100	45	8
Natural fire areas Tonto NF	1980	105,569	26,206	131,775		
REGION 3 TOTALS				1,147,503	169	18,061
REGION 4						
Teton Wilderness Bridger-Teton NF	1976/82	585,000		585,000	49	209
Sawtooth Wilderness Sawtooth NF	1982	248,518		248,518	12	46
Lake Fork FMA Payette NF	1979/81		93,030	93,030	5	1,248
Bee Hive Peak FMA Fishlake NF	1982	275,260	275,260			
High County FMA Targhee NF	1982		289,865	289,865		
West Slope FMA Targhee NF	1982		170,795	170,795		
Big Hole FMA Targhee NF	1982		150,000	150,000		
REGION 4 TOTALS				1,812,468	66	1,503
REGION 5						
Caribou Wilderness Lassen NF	1982	19,080		19,080		
REGION 6						
Eagle Cap Wilderness Wallowa-Whitman NF	1982	293,735		293,735	6	3



## APPENDIX B: SELECTED REFERENCES FOR PARK AND WILDERNESS FIRE MANAGEMENT PLANNING

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Outlines a procedure for fire management planning for parks; wilderness areas; and other wild, natural, or essentially undeveloped areas. Discusses background and philosophy of wilderness fire management, planning concepts, planning elements, and planning methods.

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**KEYWORDS:** wilderness fire management, natural fire programs, wilderness, fire management, land management planning

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The Intermountain Station, headquartered in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

The Intermountain Station includes the States of Montana, Idaho, Utah, Nevada, and western Wyoming. About 231 million acres, or 85 percent, of the land area in the Station territory are classified as forest and rangeland. These lands include grasslands, deserts, shrublands, alpine areas, and well-stocked forests. They supply fiber for forest industries; minerals for energy and industrial development; and water for domestic and industrial consumption. They also provide recreation opportunities for millions of visitors each year.

Field programs and research work units of the Station are maintained in:

Boise, Idaho

Bozeman, Montana (in cooperation with Montana State University)

Logan, Utah (in cooperation with Utah State University)

Missoula, Montana (in cooperation with the University of Montana)

Moscow, Idaho (in cooperation with the University of Idaho)

Provo, Utah (in cooperation with Brigham Young University)

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